THE

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[THIRD SERIES.]

ART. I.—*Memorial of* EDWARD TUCKERMAN; by ASA GRAY.*

ON the 15th of March last, the Academy lost one of the older and more distinguished members of the botanical section, the Lichenologist, EDWARD TUCKERMAN.

He was born in Boston, December 7, 1817, was the eldest son of a Boston merchant of the same name and of Sophia (May) Tuckerman. He was prepared for college at the Boston Latin School, whence, in obedience to his father's choice rather than of his own, he went to Union College at Schenectady. Entering as a Sophomore, he took his B.A. degree in 1837. He then entered the Harvard Law School, took his degree in 1839, and remained in residence in Cambridge for a year or two longer. In the year 1841 he went to Germany and Scandinavia, going as far north as Upsala, devoting himself, as in a subsequent visit, to philosophical, historical, and botanical studies. On his return, in September, 1842, he made, with the writer of this notice, a botanical excursion to the White Mountains of New Hampshire, with which he was already familiar. At the close of that or early in the following year he took up his residence at Union College, proceeded to the M.A. degree, and there prepared and privately published one of the smaller, but noteworthy, of his botanical papers.

In the year 1844 or 1845 he returned to Cambridge, and in the autumn of 1846, in his twenty-ninth year, he became again

* From the Proceedings of the American Academy of Arts and Sciences, vol. xxi, 1886.

an undergraduate. Applying for admission to the incoming senior class, he remarked to President Quincy that his father had broken the family tradition by sending him to another college, and that he proposed to correct the mistake. To the suggestion, that, being already an alumnus of the Law School as well as of Union, the University would willingly concede to him the earlier degrees he sought, he replied that he proposed to receive them in the ordinary way. He accordingly passed the regular examinations, took the whole routine of the studies of his class, and so was graduated with distinction in the class of 1847,—a unique but characteristic illustration of a loyal spirit, becoming "small by degrees and beautifully less."

His passion for university study was not yet quite satiated. For, two or three years later, he entered the Harvard Divinity School, passed through its course of study and prescribed exercises,—among them the delivery of a sermon in one of the Cambridge churches,—and so, in the year 1852, he became for the third time an alumnus of Harvard.

In May, 1854, he married in Boston Sarah Eliza Sigourney Cushing, who survives him, without offspring. Removing that year to Amherst, he built, with excellent taste, upon a beautiful site, the house which has ever since been their abode. Although mainly devoted to botanical investigations, his first official connection with Amherst College was that of Lecturer in History, then that of Professor of Oriental History, down to the year 1858, when he was collated to the chair of Botany, which he held to the end of his life, although of late years relieved from the duty of class instruction. The College did itself the honor to confer upon its professor the degree of LL.D.

We cannot say when or how Professor Tuckerman became a botanist. But at an early period he was intimate with Dr. Harris, then University Librarian, and with the ardent William Oakes of Ipswich, upon whom, through Dr. Osgood of Danvers, descended the mantle of Manasseh Cutler, of Essex County, the earliest New England botanist.

He must have been attracted to the Lichens almost from the beginning. For his first publications were upon Lichens of New England, largely those of his own collecting in the White and Green Mountains, in two papers, one communicated to the Boston Natural History Society in 1838 or 1839, the other in 1840. These were soon followed by papers on phænogamous botany, viz: one "On *Oakesia* a new Genus of the Order *Empetreæ*," a contribution made while he was abroad, in the summer of 1842, to Hooker's London Journal of Botany. Unfortunately, the interesting plant which he thus dedicated to his botanical associate, William Oakes, who well deserved such commemoration, proved to be a second species of *Corema*. In

1843, at Schenectady, he privately printed and issued his "Enumeratio Methodica Caricum quarundam," (pp. 21, 8vo), in which he displayed not only his critical knowledge of the large and difficult genus *Carex*, but also his genius as a systematizer; for this essay was the first considerable, and a really successful, attempt to combine the species of this genus into natural groups. It is wholly in Latin, which he much affected for scientific disquisition as well as for technical characters, and used with facility and elegance. In the same year also appeared, in the American Journal of Science, the first of his "Observations on some interesting Plants of New England." This was followed in 1848 by a second, and in 1849 by a third paper in the same Journal; these containing, *inter alia*, his elaboration of our species of *Potamogeton*, then for the first time critically studied. These papers—with one or two in Hovey's Magazine and elsewhere, at about the same date—may be said to have ended his work in phænogamous botany, although his interest in the subject never died out. For when he accepted the chair of Botany at Amherst he began the preparation of "A Catalogue of Plants growing without cultivation within thirty miles of Amherst College," which he published in the year 1875, the late Mr. Charles Frost of Brattleborough contributing the lower Cryptogamia other than the Lichens. In matter and form, as well as in typography (in which Professor Tuckerman had exquisite taste), this catalogue is one of the very best.

But it was to Lichenology that his strength, as indeed almost his whole life, was most assiduously devoted. When, in his youth, the active members of the newly organized Natural History Society of Boston divided among themselves the work of making better known the animals, plants, and minerals of Massachusetts, the study of the Lichens either was assigned to him or he volunteered to undertake it. From this came those earliest papers which have already been mentioned. Also his "Synopsis of the Lichens of New England, the other Northern States, and British America," communicated to this Academy in the autumn of 1847, which is the most considerable botanical contribution to the first volume of the Proceedings. The fourth, fifth, sixth, and seventh volumes contain other of his lichenological papers, of wholly original matter and critical character,—largely upon collections which had begun to come to him from the Rocky Mountain region, from Texas, the Pacific Coast, the Sandwich Islands, and especially from the rich materials gathered in Cuba and elsewhere by the late Charles Wright. In these years, too, he much helped the study of his favorite plants by the preparation and issue of his "Lichenes Americæ Septentrionalis Exsiccati," in six fasciculi,

or three volumes, highly valued by those who fortunately possess them. Equally fortunate are the herbaria which possess the "Caroli Wrightii Lichenes Cubæ curante E. Tuckerman," which authenticate his thorough work upon that portion of Mr. Wright's Cuban collections that he undertook to elaborate.

Passing without notice various subsidiary contributions both to journals and to the Reports of Exploring Expeditions (which, however, are all enumerated in the appended list), we come to a pamphlet which he independently published at Amherst, in 1866, entitled "Lichens of California, Oregon, and the Rocky Mountains, so far as yet known," which, small though it be (pp. 35, 8vo), is particularly noteworthy. For in this he lays down the principles and matured opinions which he had adopted, and which he firmly adhered to, for the taxonomy and classification of Lichens. These are fully exemplified in the two systematic works to which Professor Tuckerman's later years and maturest powers were persistently devoted,—works which, partly from their publication somewhat out of the ordinary channels, are by no means so well known as they should be, but which surely secure to their author the position of a master in his department,—in which, indeed, we suppose he has left behind him no superior. These works are, first, the "Genera Lichenum, an Arrangement of the North American Lichens" (pp. 283, 8vo), published at Amherst in the year 1872; second, the "Synopsis of the North American Lichens," Part I, comprising the *Parmeliacei*, *Cladoniei* and *Cœnogoniei*, published in Boston (by Cassino & Co.) in 1882. It is hoped, but it is not yet certain, that some portions of the remainder, relating to the less conspicuous but more difficult tribes, may have been substantially made ready for the printer. The loss, we fear, is irreparable; for the work cannot be completed by other hands upon quite the same lines, nor in our day with the same knowledge and insight; and Professor Tuckerman's mode of exposition is inimitable.

That which Professor Tuckerman did accomplish, however, suffices to show the wide reach and remarkable precision of his knowledge, his patience and thoroughness in investigation, his sagacity in detecting affinities, and his philosophical and rather peculiar turn of mind. He wrote in a style which—though perhaps founded on that of his botanical model, Fries, for succinctness, and that of his favorite German philosophical masters for involution—was yet all his own, and which was the more pronounced in advancing years, when, owing to increasing deafness and delicate health, he led a more secluded life. In disquisition, the long and comprehensive sentences which he so carefully constructs are unmistakably clear to those who will patiently plod their way through them, and his choice even of

unusual words is generally felicitous; but sometimes the statements are so hedged about and interpenetrated by qualifications or reservations, and so pregnant with subsidiary although relevant considerations, that they are far from easy reading. Like nests of pill-boxes, they are packed into least bulk; but for practical use they need to be taken apart.

That Professor Tuckerman could write idiomatic and clear-flowing English upon occasion, the delightful introduction to his edition of Josselyn's "New England's Rarities" demonstrates; and in the framing of botanical descriptive phrases, Latin or English, in which clearness and brevity with just order and proportion are desiderata, he had hardly a superior.

As has been said, his botanical model was Elias Fries. He had visited him at Upsala, and he kept up a correspondence with him to the end of the venerable botanist's life. He caught from Fries, or he developed independently, and cultivated to perfection, that sense of the value of the indefinable something which botanists inadequately express by the term "habit," which often enables the systematist to *divine* much further than he can perceive in the tracing of relationships. Upon this, in direct reference to Fries, and with a use of the term that seems to correlate it with "insight," Tuckerman remarks: "So great is the value of Habit in minds fully qualified to apprehend and appreciate its subtleties, that such minds may not only anticipate what the microscope is to reveal, but help us to understand its revelations." It should be remembered, however, that when Fries did the best of his work there were no microscopes of much account; and it is probable that Tuckerman would have done more, and perhaps have reached some different conclusions, if he had earlier and more largely used the best instrumental appliances of the time. One advantage, however, of his way of study, and his philosophical conception of an ideal connection of forms which are capable of a wide play of variation, was that he took broad views of genera and species. So he was quite unlike that numerous race of specialists who, in place of characterizing species, describe specimens, and to whom "genus" means the lowest recognizable group of species.

As to the vexed question in Lichenology, which came to him rather late and seemed to threaten the stability of his work, it was most natural that, at his time of life, he did not take kindly to the algo-fungal notion of Lichens, and that he was convinced of its falsity by questionable evidence.

Professor Tuckerman was much more than an excellent specialist. Happily, he did not become such until he had laid a good foundation, for the time, in general systematic botany; and his early studies show that he was a man of scholarly cul-

ture over an unusually wide range. He was at home in the leading modern languages; he wrote Latin with reasonable facility, and botanical Latin remarkably well; he had given serious attention to law, divinity, philosophy, and history; and he was fond of antiquarian and genealogical researches. He privately published (without date) a handsome edition of Josselyn's "New England's Rarities Discovered," with copious critical annotations, of 134 pages, including an introduction of 27 pages, which contains a biography of Josselyn and a sketch of the earlier sources of our knowledge of New England plants and of some of the people who made them known.* Among them is a biographical notice of Manasseh Cutler, one of the very first elected Fellows of this Academy, the earliest botanical contributor to its Memoirs,—pastor, naturalist, and statesman, the builder of New England in Ohio, probably the originator of the Dane Resolutions in Congress,—a man whose name deserves larger remembrance than it has yet received.

Professor Tuckerman was elected into this Academy in May, 1845. He was one of the corporate members of the National Academy of Sciences at Washington, and an honorary member of several of the learned societies and academies of Europe. He was still young when Nuttall dedicated to him the genus *Tuckermania*, founded upon one of the handsomer of Californian Compositæ, which holds as a subgenus. For one who did not attain the age of sixty-seven, his publications span a remarkably wide interval. It is said that he contributed several short articles on antiquarian topics to the Mercantile Journal in the year 1832. Also that, in 1832 and 1833, he assisted the late Mr. Samuel G. Drake in the preparation of his "Book of the Indians" and "Indian Wars." Then, between 1834 and 1841, he contributed to the New York Churchman no less than fifty-four articles, under the title of "Notitia Literaria" and "Adversaria," upon points in history, biography and theology. His latest botanical article was contributed to the Bulletin of the Torrey Botanical Club in 1884. A little later, possibly, are some of his contributions to the Church Eclectic, mostly pseudonymous,—critical notices of recent theological works. He was a keen critic, and very independent in his judgments. He had sounded in his time the depth of various opinions. But as he was born into, so he died, as he had lived, devoutly, in the communion of the Protestant Episcopal Church. With some interruptions, and of late under increasing infirmities, he yet continued his lichenological studies until within a few weeks before the end. Living for a long while in comparative seclusion, few of our younger botanists can have

* It appears that this was a contribution to the fourth volume of the Archæologia Americana, published in 1860.

known him personally, or much by correspondence; and most of his old associates and near friends, who knew him best and prized him highly for his sterling character, have gone before him.

ART. II.—*Notes on American Earthquakes, No.* 15; by Professor C. G. ROCKWOOD, JR., Princeton, N. J.

IN this, the fifteenth paper of this series, I have given, as in former years, a summary of such information as I have been able to gather in regard to the earthquakes of 1885 in North and South America. For the facts embodied herein I am largely indebted to the Monthly Weather Review of the U. S. Signal Service, and to a pretty careful watch of the current newspapers; but I must express here my thanks to all those persons, a somewhat numerous company, who have in one way or another personally lent their aid to my work. Among them I may be permitted to mention J. M. Batchelder, Esq., of Cambridge, Mass., Professor Charles Carpmael of Toronto, Superintendent of the Meteorological Service of Canada, C. H. McLeod of McGill College Observatory, and Dr. George Pyburn of Sacramento, California, who has given very efficient aid in collecting data in regard to Californian earthquakes.

A few items are printed in small type, being regarded as somewhat doubtful, and when the account of any earthquake rests on the authority of a single unconfirmed report, the source of the information is always given. The division of the day into twenty-four hours is again employed.

I have also again attempted to assign to each earthquake a grade of intensity. The estimate of intensity is based whenever possible upon the character of the physical phenomena reported. When no such information is available, the judgment is based upon the phraseology of the original report, taking into account the probable intensity of an earthquake in the locality in question. For example, if a despatch says briefly, "A heavy earthquake was felt" at a single place; then if this item referred to the eastern United States it might mean a *light* or even a *very light* shock, while if it referred to Peru or Central America it would probably be a *strong* or a *severe* shock. I am quite aware that such estimates have in many cases a large element of uncertainty, but at least they are the best that can be made now, and better than any one else could make at a later date and without access to the original reports. In indicating the intensity I have used again the adjectives, 1, *Very light;* 2, *Light;* 3, *Moderate;* 4, *Strong;* 5, *Severe;* 6,

Destructive, in the same sense as in my last notes (this Journal, xxix, 426); but I have added a Roman numeral to indicate the intensity according to the Rossi-Forel scale* adopted by the Italian and Swiss seismologists. The two scales may be compared thus:

Very light	= II or III.
Light	= IV.
Moderate	= V or VI.
Strong	= VI or VII.
Severe	= VIII.
Destructive	= IX or X.

1885.

Jan. 2.—$21^h\ 12^m$, a *light* earthquake (IV) occurred in Frederick County, Maryland, and Loudon County, Virginia, and adjacent districts. It was most severe in the southern part of Frederick County and affected an oval area of about 3,500 square miles, whose boundary just included Boonesborough and Newmarket, Md., Washington, D. C., and Warrenton, Va. The noise accompanying the shock was compared to that made by a loaded wagon passing rapidly over frozen ground or over a bridge, to distant thunder, and to the roaring of a chimney on fire. In some cases persons went out of their houses to see if their chimneys were not burning. The estimates of the duration of the shock were as usual very discordant, varying from two seconds to two minutes. As the tendency is to exaggerate this element, probably ten or fifteen seconds would be a liberal estimate of the duration. A fuller notice of this earthquake, with a map, was published in Science, v, 129.

* As this scale is not very readily accessible in America (it was printed in Science, v, 197), I reproduce a translation of it here for reference in connection with these papers.

I. Microseismic shock.—Recorded by a single seismograph or by seismographs of the same model but not putting in motion seismographs of different patterns; reported by experienced observers only.

II. Shock recorded by several seismographs of different patterns; reported by a small number of persons at rest.

III. Shock reported by a number of persons at rest; duration or direction noted.

IV. Shock reported by persons in motion; shaking of movable objects, doors and windows; cracking of ceilings.

V. Shock felt generally by every one; furniture shaken; some bells rung.

VI. General awakening of sleepers; general ringing of bells; swinging of chandeliers; stopping of clocks; visible swaying of trees; some persons run out of buildings.

VII. Overturning of loose objects; fall of plaster; striking of church bells; general fright without damage to buildings.

VIII. Fall of chimneys; cracks in the walls of buildings.

IX. Partial or total destruction of some buildings.

X. Great disasters; overturning of rocks; fissures in the surface of the earth; mountain slides.

Jan. 3.—About 2^h a *very light* shock (III), lasting about five seconds, occurred at Laconia, N. H.

Jan. 4.—6^h 6^m, a *light* earthquake (IV) occurred at Peekskill, Sing Sing, Tarrytown and other places along the lower Hudson. It was accompanied by a rumbling sound and was strong enough to shake windows, etc., but owing to the early hour it was not generally noticed, as it was not strong enough generally to awaken sleepers.

Jan. 15.—4^h 10^m, a *very light* shock (III) at Shæfferstown, Pa. —*Philadelphia Record.*

Jan. 18.—About 5^h 30^m or 5^h 45^m, a *very light* shock (II) at Garrettsville, Portage County, Ohio.—*U. S. Weath. Rev.*

Jan. 26.—1^h 33^m, 120th meridian time, a *moderate* earthquake (V) occurred in central California from San Francisco northward to Napa and Petaluma, that is, over a distance of about forty miles north and south. At San Francisco the duration was ten seconds, direction east-west. At San Rafael, time 1^h 38^m, direction east-west. At Oakland, time 1^h 30^m, direction northeast to southwest or west, accompanied by a rumbling noise. The time adopted above is that given by the U. S. Signal Service observer at San Francisco. At 20^h 56^m another lighter shock (IV) was felt in the same district, in regard to which the San Francisco Signal Service observer says: "It began with a slight tremulous motion, which gradually increased in violence and terminated in a quick sharp shock of three seconds' duration."

Jan. 27.—4^h, "a severe and prolonged shock (V?) was felt at Valparaiso."—*Nature.*

Jan. 30.—21^h 38^m, 120th meridian time, a *very light* shock (III) at Sacramento, Cal., lasting several seconds, direction northeast to southwest.—*U. S. Weath. Rev.*

Jan. 31.—5^h 5^m, a *very light* shock (III), with a rumbling sound like distant thunder, was felt in Cortlandt, Yorktown and other places in the northern part of Westchester County, New York.—*N. Y. Tribune.*

Feb. 2.—7^h 10^m, a very light earthquake (III) was felt at Wytheville, Wythe County, Virginia, with a sound like the rumbling of distant thunder, which seemed to come from the northwest. Apparently it was confined to the immediate vicinity of Wytheville, as inquiries by circular to adjoining counties brought replies from Marion, Smyth County, southwest; Rural Retreat, Wythe County, and Independence, Grayson County, south; Hillsville, Carroll County, southeast; Pulaski Station, Pulaski County, northeast; and Bland Court House, Bland County, north, at none of which places was it felt.

Feb. 3.—0^h 20^m, a rumbling of earthquake at Huntingdon, Quebec.—*Meteorol. Serv. of Canada.*

Feb. 5.—23^h, } Two *moderate* shocks (V?) at these hours at
Feb. 6.— 2^h, }
Geyser Springs, Sonoma County, Cal.—*San Francisco Chronicle.*

Feb. 8.—A telegram from the City of Mexico states that on this date *strong* earthquake shocks (VII?) were felt at Tequi Sixtlan (?) and Niltepec in the State of Oaxaca, with the fall of one house in the latter place.—*U. S. Weath. Rev.*

Feb. 22.—18^h 53^m, a *very light* shock (III) at Newcastle, Placer County, Cal.—*Sacramento (Cal.) Bee.*

Feb. 25.—0^h 30^m, a slight rumble of earthquake at Huntingdon, Quebec.—*Meteorol. Serv. of Canada.*

Feb. 26.—The San Francisco Chronicle of this date says: "The earthquakes still continue in the vicinity of Susanville. One shock recently, it is said, shook down the curbing of a well in that town. The shocks appear to be local, as none are felt one hundred miles from here." This locality is in Lassen County in the extreme northeastern part of the State.

March 8.—20^h, a *light* earthquake (IV), with a heavy rumbling sound, was felt in Lancaster, Pennsylvania, shortly after 20^h. Buildings trembled and church services were interrupted.

March 11.—10^h 57^m, two *very light* shocks (III), and at 11^h 7^m a third at St. Johns, Quebec, "in a snow storm;" felt also at Waterloo, Quebec.

March 18.—12^h, a *very light* shock (III) a few minutes past noon at Contoocook, N. H., and vicinity.

March 18.—19^h 45^m, a *very light* shock (III) at Point des Monts, Quebec.—*Meteorol. Serv. of Canada.*

March 23.—20^h 22^m, loud rumbling of *light* earthquake (IV) at Huntingdon, Quebec; "felt all over the country."—*Meteorol. Serv. of Canada.*

March 30.—22^h 34^m, at Mendoza, in the Argentine Republic, occurred three *strong* shocks (VI), lasting about eight seconds. "They consisted in a slow movement of inclination toward the west and a quick return to the east, and for thirty seconds after the last shock a subterranean noise was heard like the rumbling of a distant railway train."—*La Nature.*

March 30.—28^h 56^m, 120th meridian time, a *strong* shock (VI) was felt in central California, extending from San Rafael, Marin County, on the north, to Monterey, Salinas and Hollister on the south. The time stated above is that given by the Signal Service observer at San Francisco, where the direction was east-west. At San Rafael the reported time was 23^h 30^m, and three shocks were felt from the southwest, lasting twelve seconds and sufficiently strong to stop clocks. At San José the reported time was 23^h 35^m, direction east-west. At Salinas and Monterey, at 23^h 45^m, two distinct shocks sufficient to awaken sleepers. At Hollister five distinct shocks during the night, the most severe at midnight, by which several brick buildings were cracked and plaster fell.

March 31.—About 3^h, a *very light* earthquake (III) at Fall Brook, San Diego County, California.—*U. S. Weath. Rev.*

April 2.—7^h 25^m, a *light* shock (IV) at Merced and Fresno, California. A *very light* shock (III) was reported at Sacramento, at 7^h 15^m, which, although somewhat widely separated, may have been part of the same.

April 3.—10^h 15^m, two *very light* shocks (III), northeast to southwest, at Sacramento, California.—*U. S. Weath. Rev.*

April 7.—In southern California a *light* shock (IV) was reported from Bakersfield, Kern County, at 2^h 30^m, direction north-south, with rumbling; and from Santa Barbara and San Buenaventura at 2^h—at the latter place two shocks, direction northeast-southwest.

April 11.—20^h 5^m, 120th meridian time, a *strong* earthquake (VI) was very generally felt in central California. It was felt at numerous places from the coast to the vicinity of the Sierra Nevada, and from Marysville on the north to Monterey and Hanford on the south, with an extension of the boundary toward the southeast so as to include Keeler on Owens Lake, which is east of the Sierra. It was more severe in a tract extending from southwest to northeast across the district above indicated, including Monterey, Salinas, Merced and Stockton. Here it was strong enough to awaken sleepers, to stop clocks, to swing chandeliers, and to cause people to rush from their houses in alarm. At the more distant places, as Marysville, San Rafael, San Francisco, Hanford and Keeler, it was much less strong, being reported as slight, long and slow, very slight, very perceptible, a gentle tremor. The directions reported were: north-south at Ione, Stockton, Merced, Salinas; east-west at Sacramento, San Francisco, San Jose and Monterey, although at Sacramento two observers said north-south; southwest-northeast at San Rafael and northwest-southeast at Keeler. The duration varied from two seconds at Keeler to twenty seconds at San José and San Francisco, and fifteen seconds at Ione, and in several places two shocks were noticed. The one minute and ten seconds duration reported from Merced was probably exaggerated. In the outline of the area of this earthquake given upon the following map, it is quite probable that the eastern boundary would also have been convex if fuller reports had been available from that direction, but that is a much more thinly populated portion of the State, from which there were no reports.

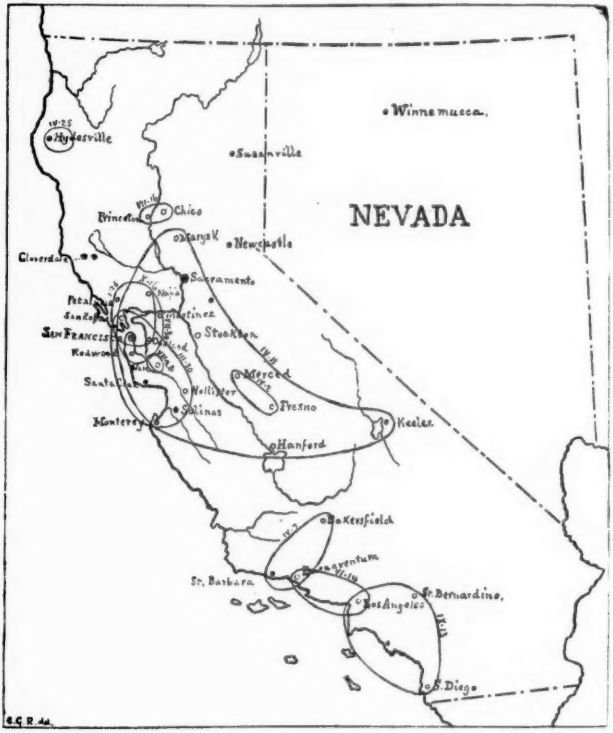
April 13.—19^h 20^m, at Unalashka, Alaska, a *light* shock (IV), lasting only a few seconds, reported by the U. S. Signal Service observer.—*U. S. Weath. Rev.*

April 16.—9^h, at St. Fidèle and Murray Bay, on the lower St. Lawrence, a *light* shock (IV).—*McGill College Obs'y.*

April 18.—Shortly before midnight, exact time not known, a *moderate* shock (V) at Keeler, Inyo County, California, sufficiently severe to disturb sleepers. It was preceded by a loud report as of an explosion.—*U. S. Weath. Rev.*

April 25.—20^h 20^m, a *very light* shock (III) in Humboldt County, California, reported at Hydesville and Blue Lake.

April 26.—5^h 30^m, a rumbling of earthquake at Point des Monts, Quebec.—*Meteorol. Serv. of Canada.*



April 28.—17^h 10^m, a *light* earthquake (IV) at Guilford, Conn., direction east-west, lasting one second.—*New Haven Palladium.*

April 30.—5^h 30^m, a *very light* shock (III) at Unalashka, Alaska.—*U. S. Weath. Rev.*

May 1.—21^h 30^m, local time (24^h 21^m, 75th meridian time), a *light* shock (IV) at Winnemucca, Nevada.—*U. S. Weath. Rev.*

May 3.—About 9^h two *very light* shocks (II) at Dover, Maine. —*J. M. B.*

May 3.—23^h 30^m, local time, a *very light* shock (III) at Olympia, W. T. Light shocks continued until 1^h 30^m of the 4th.—*U. S. Weath. Rev.*

June 14.—3^h 14^m, 120th meridian time, a *moderate* earthquake (V) occurred in southern California, reported at San Buenaventura, Ventura County, and Los Angeles and Cahuenga, Los Angeles County. At the former place two shocks, south to north, were noted, lasting twenty seconds. At the last two places the duration was two or three seconds and direction east-west. It was sufficiently strong to awaken sleepers.

June 25.—20^h 30^m, a *very light* shock (III), north to south, at Salinas, California.—*U. S. Weath. Rev.*

June 27.—5^h 26^m, at Olympia, W. T., a *light* shock (IV), east to west, with rumbling noise.—*U. S. Weath. Rev.*

July 9.—1^h 20^m, at Santa Barbara, California, "five (*moderate*) earthquake shocks (V) occurred between 1^h 20^m and 8^h 15^m, each one of long duration and sufficient severity to awaken the greater number of the inhabitants."—*U. S. Weath. Rev.*

July 9.—A Norwegian bark which sailed northward from Acapulco, Mexico, on this day, reported: "The first day out we felt three distinct earthquakes with thunder and lightning." The distance is too great for this to be identical with the last item.—*Sacramento (Cal.) Bee.*

July 16.—22^h 15^m, a *light* shock (IV) at Princeton, Colusa County, and Chico, Butte County, California. Windows rattled and sleepers were awakened.

July 23.—1^h, at this time began an eruption of Cotopaxi in Ecuador, causing an emission of lava with stones and ashes. The explosions shook the earth to a considerable distance around, rattling doors and windows.—*Nature.*

July 23.—12^h 25^m, a *moderate* earthquake (VI), preceded by rumbling noise, was felt at San José, Santa Clara County, and Centerville, Alameda County, California. At the former place the oscillations were east-west and duration three seconds. Clocks were stopped and slight damage occurred to fragile wares in stores. At Centerville the time was reported 12^h 20^m and direction north-south. A *very light* preliminary shock (III) had been noticed here at about 19^h of the previous evening.

July 31—16^h 10^m, a *strong* earthquake (VII) was felt, north to south, at Cloverdale, Sonoma County, California. The walls in several houses were cracked.—*San Francisco Chronicle.*

Aug. 13.—A *light* earthquake (IV) occurred in the Blue Ridge Mountains in Wautega County, in the northwest corner of North Carolina. It was accompanied by a noise resembling thunder, and was also felt at Boone, ten miles from the mountains.

Aug. 13.—A *light* shock (IV) was felt at St. Kitts, West Indies. —*N. Y. Tribune.*

Aug. 14.—23^h 5^m, a *very light* shock (II) at Garrettsville, Portage County, Ohio.—*U. S. Weath. Rev.*

Aug. 19.—A *moderate* shock (V) at Valparaiso, Chili.—*N. Y. Times.*

Aug. 30.—*Light* shocks (IV) felt at Jamaica, W. I., in the evening.—*N. Y. Tribune.*

Sept. 4.—9^h 40^m, a *light* shock (IV) was felt in the villages of Campbellford, Hastings and Norwood, Ontario.—*U. S. Weath. Rev.*

Sept. 13.—4^h 34^m, a *light* shock (IV) in southern California. It was felt along the coast from Los Angeles to San Diego and inland to San Bernardino. At Los Angeles the direction was given as southwest to northeast; at San Diego, where two shocks were felt, lasting in all twelve seconds, the direction was east-west; at Murrietta it was the same and three shocks were reported; at Cahuenga it was northwest-southeast and duration about three seconds. The time stated above is that reported by the U. S. Signal Service observer at San Diego, reports at other stations vaguely given varied from 4^h to 5^h.

Sept. 26.—16^h, reports of earthquake at this time in Washington County, Pennsylvania, were due to the passage of a meteorite and not to any terrestrial disturbance.

Oct. 9.—8^b, a *moderate* shock (V), south to north, at Olympia, W. T.

Oct. 9.—23^h 36^m, a *moderate* earthquake (V) was felt in Virginia. It was more severe at Lynchburg, Campbell County, and Staunton, Augusta County, and vicinity, where windows and furniture were shaken and some persons ran out of their houses in alarm. It was felt also at Petersburg, where many were waked by shaking windows; very slightly at Richmond; and by one person, at 23^h 42^m in Washington, D. C. In the latter place it was not noticed at the Signal Service office, nor at the Naval Observatory, and left no trace on the records of the self-registering barometers. At Lynchburg the direction was north-south, and both here and at Variety Mills in Nelson County, a second shock occurred about an hour later.

Oct. 10.—Between 1^h and 2^h three *very light* shocks (III), each of about one second duration and separated by an interval of six seconds, at East Portland, Oregon.—*U. S. Weath. Rev.*

Oct. 11.—In the evening a *destructive* earthquake (IX) occurred throughout the Republic of Nicaragua. It was felt at San José at 22^h 30^m. The following account is given by Earl Flint, M.D., of Rivas.

"The earthquake was more prolonged than that which was felt at Chinendega in 1851. The shock was general throughout western Nicaragua. it was also felt to the eastern part of the axial line, beyond the lake, and along the eastern slope of the main Cordilleras, although it was less severe in that region. Reports from prefects give the greatest force at Leon, Old Chinendega and Managua. Leon cathedral was fractured in various places; Laborio church tower was telescoped, and other churches were injured. The government house, barracks, seminary, Institute. and bishop's palace were also damaged, and most of the adobe houses lost partition walls. Managua and Chinendega suffered similar losses, though somewhat less. The shock began with a slight and prolonged oscillation northwest and southeast, and its duration allowed most of the people to reach the streets and yards; but those who had retired, being delayed in opening doors, were bruised by the falling tiles and partition walls. Five deaths occurred at Leon and one at Managua."—*U. S. Weath. Rev.*

Oct. 16.—$4^h\ 45^m$, 120th meridian time,—a *light* earthquake (IV) occurred in central California, being very faint at San Francisco, light at San Rafael and heavier at Napa and Santa Rosa. At Napa the direction was north-south and a slight preliminary shock was felt at midnight. At Santa Rosa three shocks were noted, direction northeast-southwest. Almost exactly the same region had been shaken on January 26.

Oct. 17.—$17^h\ 30^m$, a *light* earthquake (IV) occurred at Sandersville, Washington County, Georgia.

Oct. 26.—Between 1^h and 2^h two *very light* shocks (III) at Frisco, Utah, each lasting about two seconds and accompanied by a rumbling noise.—*U. S. Weath. Rev.*

Nov. 11.—$11^h\ 58^m$, a *very light* earthquake (III) at Helena, Montana, of about three seconds duration.—*U. S. Weath. Rev.*

Nov. 19.—Between 13^h and 20^h earthquake waves were indicated on the coast survey tide-gauge at San Francisco. "They were thirty-five minutes apart and were as great as those observed during the great upheaval in Java some years since."—*Nature.*

Dec. 7.—22^h, at Quamichan, B. C., an earthquake (IV) reported by the observer of the Meteorol. Serv. of Canada.

Dec. 8.—In the evening a *moderate* earthquake (V) occurred in the vicinity of Puget Sound, W. T. The principal shock occurred at $22^h\ 40^m$, 120th meridian time, and was felt as far south as Olympia, where the motion was east-west and was sufficient to arouse sleepers. At East Sound three light shocks were reported at $22^h\ 35^m$; two heavy ones, rattling dishes at $22^h\ 40^m$; two light ones at $23^h\ 15^m$, and a somewhat heavier one at $23^h\ 50^m$. At Victoria, B. C., the time given was $22^h\ 12^m$ (local time ?), a loud rumbling was heard and the duration was ten or fifteen seconds. It was also reported from Port Angeles and Salt Springs Island.

Dec. 11.—$2^h\ 4^m$, a *moderate* earthquake (V) occurred in Chili and Peru. It was reported from Valparaiso, Arica, Taena and Serena, but was most seriously felt at Iquique where buildings were shaken. Five minutes after the first shock a second slight

shock followed, and after another ten minutes a third was felt, which was followed later by two more slight shocks. The sea was extraordinarily agitated and the agitation continued with diminishing intensity through the 12th.

Dec. 18.—0^h 30^m, a *very light* shock (III) at Tatoosh Island in the extreme northwest of Washington Territory. It lasted about five seconds and was followed by a second shock about ten minutes later.—*U. S. Weath. Rev.*

Dec. 18.—At Amatitlan, Guatemala, a place of about 5,000 inhabitants, situated twenty-four miles south of the city of Guatemala, slight but frequent earthquakes occurred, continuing all day from 2^h to 17^h 22^m when a heavy shock was felt. At 17^h 36^m the heaviest and most *destructive* shock (IX) came, throwing down many walls and houses already fissured by the earlier shocks; people were thrown down and the air was filled with the dust from the fallen adobe houses. One hundred and thirty-one shocks were felt the first day, principally from east to west, eighty-one of which occurred between 16^h and 17^h 36^m. The second day was nearly as bad, and the shocks continued for some days subsequent. A government commission, consisting of Professor Rockstroh and Mr. Walker, visited the place and reported the total destruction of the village of San Vincente Pacaya and an increase in the amount and temperature of the water emitted by the hot springs about Lake Amatitlan, but no increased activity in the volcano of Pacaya.

Dec. 28.—Between 3^h and 4^h, at Santa Cruz, California, two *light* shocks of earthquake (IV); the vibrations were north and south.—*U. S. Weath. Rev.*

Dec. 28.—19^h 5^m, a loud explosion accompanied by a rumbling sound and a *very light* earthquake shock (III) occurred at Bloomington, Illinois.

Dec. 29. Between 4^h 30^m and 5^h 30^m some *very light* shocks (III) were reported at Hartford, Connecticut.

Dec. 30.—9^h 46^m, a *moderate* earthquake (V) was felt in the vicinity of the bay of San Francisco. It extended from Redwood City and San Mateo on the south, to Napa and Petaluma on the north, and inland to Port Costa and Martinez, Contra Costa County. At San Francisco it was preceded by a very light shock, and the main shock lasted ten seconds with a north-south motion, but here it was not very generally noticed by people in the open air. At Oakland the duration was six seconds, motion east-west, with a rumbling noise. At San Rafael houses rocked and a loud noise was heard. At Petaluma and at Redwood City the direction was north-south. This is the third earthquake in this same district during the year; the others were on January 26 and October 16.

The above list for 1885 contains 71 items, not counting the one

of Sept. 26, of which five are in small type. They may be geographically classified thus:

Canadian Provinces	8
New England	5
Atlantic States	9
Mississippi Valley	3
Pacific Coast of U. S.	34
Alaska	2
Mexico	1
Central America	2
West Indies	2
Ecuador	1
Peru and Chili	3
Argentine Republic	1
	71

By seasons they are classified thus: Winter, 24 (Dec. 8; Jan. 9; Feb. 7); Spring, 22 (Mar. 8; Apr. 11; May 3); Summer, 14 (June 3; July 6; Aug. 5); Autumn, 11 (Sept. 2; Oct. 7; Nov. 2); Spring and Summer together, 36; Autumn and Winter together, 35.

Those estimated as having an intensity of VI or over, on the Rossi-Forel scale, were as follows:

VI. March 30, Argentine Republic; March 30, April 11, July 23, California.
VII. February 8, Mexico; July 31, California.
IX. October 11, Nicaragua; December 18, Guatemala.

The last two were the only ones in which serious injury to buildings or loss of life was reported.

So large a proportion of the earthquakes of the year have occurred in California, that I have added (p. 12) an earthquake map of that State for 1885, from which it will be seen that the bay of San Francisco is situated in a particularly shaky region. The greater number of earthquakes which are reported here may be in part due to the better facilities for collecting data, as this is the most thickly settled part of the State, but it can hardly be attributed to that cause alone. Upon the map the area of each earthquake is enclosed by a line upon some part of which the date is given. The black dots represent shocks which were reported from one place only. At Sacramento this occurred twice in the year. The map will also show what parts of the State were shaken more than once; thus San Francisco and San Rafael were within the areas of five distinct earthquakes.

I append a list of earthquakes in 1883 and 1884, which have come to my knowledge since the reports for those years were printed. None of them call for special comment.

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1883.

Nov. 25.—Hour not stated, an earthquake of seven or eight seconds with subterranean noise was felt at Curaçoa, Coro, Maracaibo and Churuguara, Venezuela, repeated on the 26th.—*L'Astronomie.*

1884.

The following earthquake notes from South America are taken from a list of earthquakes published by M. C. Detaille in L'Astronomie, 1885 (p. 183). Most of the reports are from Valparaiso, and when no place is stated Valparaiso is to be understood.

Jan. 1.—3^h 10^m, a strong shock at Valparaiso with subterranean noise.

Jan. 5.—15^h, a long shock.

Jan. 7.—3^h 8^m, three distinct shocks each continuing some seconds. 20^h 18^m, a strong shock but of short duration.

Jan. 14.—13^h 15^m, a sharp double shock was felt in Jamaica. At Kingston the first shock lasted about three seconds and was followed after an interval of two seconds by a second shock lasting about five seconds. It was felt over nearly the whole of the island.—*Nature.*

Feb. 5.—3^h, a strong shock at Valparaiso.

Feb. 8—9^h 30^m, a rather strong shock.

Feb. 9.—5^h 30^m, a strong shock.

Feb. 14.—3^h 30^m, a strong shock.

Mar. 3.—3^h 35^m, a strong shock.

Mar. 13.— 23^h 25^m, a strong shock.

Mar. 14.—23^h, a strong shock.

Mar. 22.—17^h 15^m, a strong shock.

Mar. 23.—4^h, two shocks; another at 17^h.

Mar. 24.—4^h, a weak shock.

Mar. 25.—5^h, a rather strong shock.

Mar. 28.—16^h, a very strong shock.

April 9.—3^h 45^m, two strong shocks.

April 11.—2^h 15^m, rumbling and strong shock.

April 14.—7^h 15^m, feeble shock.

April 15.—3^h 30^m, a strong shock followed by two less strong.

April 18.—22^h 50^m, a strong and prolonged shock with thunder, duration 30 seconds.

April 25.—7^h 15^m, strong shock coming from the south, preceded by a subterranean noise.

April 29.—4^h 15^m, three very light shocks.

May 3.—15^h 40^m, very long and strong shock.

May 5.—17^h 15^m, light shock.

May 8.—18^h 10^m, feeble shock. 19^h 44^m, very strong and vertical shock.

May 13.—3^h 45^m, a very strong and very prolonged shock.

May 14.—6^h 30^m, very long trembling without great shock.

July 4.—4^h 20^m, at Ponso Alegre, Brazil, a village about 200 miles west of Rio Janeiro, a shock from north to south of some seconds duration.

July 6.—8^h 15^m, at Valparaiso, a strong short shock preceded by a rumbling.

July 9.—0^h 15^m, a very long shock, not very strong.

July 15.—12^h, two short but rather strong shocks.

July 18.—5^h, at Nicaragua, a strong shock; also at 8^h with subterranean noise.

July 18.—22^h 30^m, a very long continuous shock lasting about one minute at Valparaiso.

July 19.—7^h and 8^h, shocks at Nicaragua.

July 29.—6^h, a shock at Nicaragua.

Aug. 15.—A shock was felt at sea on the ship "Charles Dennis" in lat. 17° N. long. 75′ W. This position is in the Caribbean Sea about 100 miles southeast of Jamaica.

Sept. 25.—16^h 6^m, at Iquique, Peru, a strong and prolonged earthquake, south to north, duration 35 to 40 seconds. The bells in the cathedral were rung and the cross had a decided motion.

Oct. 6.—0^h 45^m, at Valparaiso, a very long and very strong shock somewhat dangerous.

Oct. —.—Several shocks at the end of October.

Nov. 6.—Capt. James Cooper of the ship "Struan," reports two shocks (IV) direction southeast to northwest, duration thirty seconds and twenty seconds respectively, with an interval of about one minute between them, in lat. 4° 17′ N.; long. 79° 40′ W., which is in the Pacific Ocean, about 100 miles from the coast of Colombia. This was probably connected with the earthquake on this date in Colombia, mentioned in the last "Notes." (Am. Jour. Sc. xxix, 435.)—*U. S. Weath. Rev.*

Nov. —.—At Valparaiso, "numerous shocks all the month of November."

Princeton, N. J., April 13, 1886.

ART. III.—*Observations on the Tertiary and Grand Gulf of Mississippi;* by OTTO MEYER, Ph.D.

I HAVE spent some time recently in Mississippi, mainly for the purpose of determining the relative positions of the Marine Tertiary and the Grand Gulf formations in the State. Through part of my journey, that is, from Jackson to Terry and from Pelahatchee to Brandon, I had the company of Mr. T. H. Aldrich, and I am greatly indebted to him for calling my attention to the places in Mississippi which might yield me information.

The natural valleys which probably give the best information about the stratification in Mississippi are those of Pearl River and the Chickasawhay at their lowest water level. At the time of my visit, however, the water was too high for such an exploration, and the only means for determining the contact of the Grand Gulf and Tertiary seemed to be systematic examination of the railroads near the frontier of the two formations.

1. Along the railroad south of Vicksburg, the Vicksburgian, covered by Loess, can be traced along for about a mile; then the Loess seems to cover everything.

2. The railroad from Jackson to Natchez has a narrow gauge, and between Jackson and Raymond shows no deep cuts. In Raymond a clayey sand is to be seen.

3. On the railroad from Jackson to New Orleans we find Tertiary limestone alternating with softer strata one mile north of Byram station, all containing Orbitoides and Pecten. In Byram occurs marl with Vicksburgian fossils. Five and a half miles south of it, that is, half a mile north of Terry, on the creek at the iron railroad bridge, the first sure outcrop of Grand Gulf is found.

The following profile of the Grand Gulf strata north of Terry was taken by Mr. Aldrich and myself:

(*c*) Light sandy clay ..... 10 feet
(*b*) Sandstone, hard above, softer below, containing small nodules of green clay or corresponding cavities..... 7 feet
(*a*) Green sandy clays ..... 5 feet to water's edge

Three and a half miles south of Terry, a deep cut about 1,400 feet long, shows a remarkable exposure of Grand Gulf strata. They are laminated sandy clays and clayey sands. The fine lamination of the clays is made very conspicuous wherever water runs over them. Laminæ of iron concretions also make the stratification more conspicuous. The northern two-thirds of the cut shows a very strong northern dip, abruptly turning over southward in the remaining third with an equally strong dip. The height of the cut at the anticlinal is twenty-

five feet, twenty feet of it composed of these clays. Taking the dip into consideration the total thickness shown is about forty feet. Small pieces of lignite are disseminated through the layer, but no fossils were found by Mr. Aldrich and myself. Not only the general dip of the strata in this cut, as mentioned, changes suddenly, but besides this, the *stratification shows cross-bedding.** Between this cut and Terry ledges of white Grand Gulf sandstone, several feet thick, crop out at different places.

In recapitulation we have Vicksburgian strata occurring in Byram station and Grand Gulf strata occurring about five miles south of it, but the contact of the two formations cannot be observed along the railroad.

4. On the railroad from Meridian to New Orleans the Marine Tertiary reaches at least as far as Heidelberg, Jasper County, for there is blue limestone, from which I collected *Orbitoides* and *Pecten Poulsoni* in an abandoned quarry about one mile and a half southeast of this town. Walking along the railroad we meet a clay of a light greenish blue color at a point four miles south of Heidelberg. At a point eleven miles south of this town (south of Erata, Jones County) the railroad cuts about ten feet of gray sandy clays and white sands without fossils.

5. In Pelahatchee on the Vicksburg & Meridian Railroad we find Marine Tertiary clays with *Pecten calvatus?* Mort., *Scalaria sp.*, teeth of sharks and *Miliobates*, vertebra of fish and clayey concretions containing casts of shells, especially of *Protocardia*. Three miles west of it we meet the first cut of Grand Gulf strata—laminated clays—but the contact of the two formations cannot be observed here.

6. Walking farther west from the just mentioned cut of the Grand Gulf clays toward Brandon, we meet another exposure of these laminated clays a mile distant. They have a thickness of more than twenty feet and *show a very strong westward dip*. Another mile farther on, the same strata, of about equal thickness, are nearly horizontal. Another exposure is met about one mile and a half still farther west. It consists of laminated clays of about eighteen feet thickness, containing impressions of leaves. Sometimes the beds are more sandy, and in a few places they show cross-bedding. These clays are here enclosed in two lignitic streaks. The lower streak consists of almost pure lignite. Below this lower lignitic streak there are seen gray clayey sands without visible stratification. These sands at this point were not examined as to whether they contain fossils or not. The dip in this exposure, which consists of two connecting cuts, is west. The next cut is about a mile

* Discordante Parallelstructur.

farther west. It contains the same laminated clays with cross-bedding and at the bottom the gray clayey sands of the preceding cut are seen. They were here examined and found to contain extremely friable casts of small bivalves, apparently marine. Near the top of the laminated clays there is a streak of kaolin.—*This whole material of about twenty feet thickness is overlaid by a strip of limestone containing Pecten Poulsoni, Orbitoides, etc.* A dip in this cut is not apparent. Going farther toward Brandon no sure Grand Gulf strata were seen, but outcrops of limestone occur at two or three points at the same height with, or somewhat higher than the railroad track. Approaching Brandon and about half a mile from the station marine strata of about fifteen feet thickness are seen. They consist of sands overlaid and underlaid by ledges of limestone, all the beds containing *Pecten Poulsoni* and *Orbitoides*. The sands are sometimes clayey and at one place there are among them stratified clays of a few feet thickness which are not laminated, and contain on the planes of stratification shells and shell detritus. At Brandon station the limestone and patches of the sands are seen; and going west of the station hard limestone ledges, alternating with softer material, containing Pecten and Orbitoides occur as far as two miles west from Brandon.

The relation of the heights of all the above-mentioned cuts is as follows: The railroad track rises from the point two miles west of Brandon toward Brandon, continues to rise to the point where the contact of the Grand Gulf and marine limestone can be seen (about four miles east of Brandon); continues farther to rise for some distance in the Grand Gulf region and then falls down toward Pelahatchee.

Recapitulating these observations: Between Pelahatchee and Brandon the railroad cuts through, for a length of five miles, a belt of Grand Gulf strata, which are situated at a higher level than the marine strata west of it and which are either nearly horizontal or strongly dipping west. The Marine Tertiary of Brandon rises toward these Grand Gulf strata, and at the point where the two formations meet the marine limestone has a thickness of only two feet and overlies the Grand Gulf clays.

Those geologists who object to the conclusion from this that the Grand Gulf is older than the Marine Tertiary have the choice between two hypotheses. They can either consider this whole region of laminated clays, lignite, etc., with this peculiar dip, as not belonging to the Grand Gulf formation, or they can consider all these exposures as Grand Gulf with the only exception of that one where the orbitoidic limestone is seen on the top. After a careful examination of this region I am unable to share in either of these hypotheses.

7. In Newton, Newton County, at the Vicksburg & Meridian Railroad, laminated clays dipping east, apparently belonging to the Grand Gulf formation, may be seen. Three miles east of Newton there is a vertical railroad cut two hundred feet long and about fifty feet high affording the following profile:

(*c*) Clayey green sands of varying quality, sometimes with hard ledge-like nodules, numerous well preserved fossils; nearly	40 feet
(*b*) Reddish sand, somewhat lignitic	4 feet
(*a*) *Laminated clays, cross-bedded* with pockets of sand. They either alternate with or are overlaid by lignitic sandy clays or clayey sands, scarcely stratified, *with numerous lignitized plants and roots erect in natural position*	10 feet

The stratum "*c*" is seen on the surface 1,000 feet west from the cut on the railroad track, and therefore the dip must be west. I collected in this stratum "*c*," in less than a day, 105 species of fossils. The position of the lignitized plants in the stratum "*a*" shows that they grew on the spot, apparently in very shallow water (swamp?).

The above is the account of my efforts at eight different points to find the contact of the Grand Gulf beds and the Tertiary. The following observations are less directly connected with this question.

Greensands south of Enterprise.

The same clayey greensands, mentioned above, from Newton (stratum "*c*") occur in cuts of the railroad between Meridian and New Orleans, four miles south of Enterprise near Wautubbee, and are here underlaid by white, micaceous, cross-bedded sands, which attain a thickness of at least twenty feet and sometimes contain clays. These greensands are here very variable in thickness and in petrographic and paleontological qualities. Sometimes they are clayey, sometimes stratified, hardened and lignitic. At one point occurs the same ledge-like nodules as in Newton, containing *Ostrea sellæformis* C. I collected here 110 species, agreeing mostly, although not entirely, with those in Newton, among them two species of Cephalopods. The description of this Wautubbee-Newton fauna will appear in the Journal of the Cincinnati Society of Natural History for July, 1886. If I am not mistaken the same bed occurs at the tunnel west of Meridian and I think it is identical with a greensand bed which can be seen on the Chickasawhay at the bridge in Enterprise, underlying my bed "*b*"* (Claiborne profile). If this is so, the bed ranges stratigraphi-

* See this Journal, xxx, pp. 69, 70, 71, 1885.

cally immediately below the Claiborne profile and the paleontological evidence points to the same result and shows it to be parallel with the strata in Lisbon, Ala. After this position is determined it will be of interest in regard to the age of the Jacksonian to notice that the following species of this fauna occur in Jackson and are not known from the Claiborne sand: *Arca aspera* C., *Leda multilineata* C., *Pecten scintillatus* C., *Mitra pactilis* C. *var. dumosa* C., *Distortrix septemdentata* Gabb, *Solarium bellastriatum* C., *Flabellum Wailesii* C.; and the following species are known only from the Vicksburgian: *Corbula engonata* C., *Chama Mississippiensis* C., *Caricella reticulata* Aldr.

Profile of the strata in Jackson.

The profile of the strata near Jackson, taken by Mr. Aldrich and myself at various points, is as follows:

(*f*) Clay; blue below, lighter above, containing a large number of small bivalves, *Kelliella?*, *Corbula*, *Leda* and crab-claws. The shells are either very thin and soft or entirely dissolved, leaving only a few impressions	20–25 feet
(*e*) Glauconitic marl, varying in distinctness, containing Pecten, various Bryozoa and corals, concretion-like Madrepora (nigger-heads), all in abundance, and in addition to them some Jacksonian fossils, about	2 feet
(*d*) Jacksonian shell marl. Yellowish; or yellowish above and blue below. At one point this subdivision of this stratum is marked by a layer of *Rostellaria* in great quantity	10–15 feet
(*c*) Dark lignitic clay, without fossils at some points, but at others containing pockets of green sand full of Jacksonian fossils, bivalves numerous	about 5 feet
(*b*) Earthy lignite	20 inches
(*a*) Gray sandy micaceous clay	

It will be seen that this profile differs from a profile given by Mr. D. W. Langdon* in that he puts strata "*e*" and "*f*" together. About a mile south of Jackson clays occur, which may be or may not be identical with the clays in "*f*." Mr. Langdon observes clays on the river south of Jackson only a few feet above the water, but not far from the river clays are to be found at heights of more than fifty feet above the river level. I have little doubt that the lignitic, non-fossiliferous stratum with very strong dip between Jackson and Byram will be found on examination underlying the Jacksonian as well as the Vicksburgian.

* This Journal, xxxi, p. 202, 1886.

The Jacksonian stratum "*d*" occurs at Moody's Branch at a higher level than southeast from there at the bridge over the Pearl River. This would indicate a southern dip. On the other hand, following Moody's Branch toward its mouth in a southeastern direction the older strata dip up stream. Stratum "*e*" is seen at the uppermost part of the creek two feet above the water; a few hundred yards below, its surface is five feet above the water, and farther below, the whole stratum is about four feet above the water. Supposing a difference in the water level of four feet even, which must be a maximum there, there is yet a northern dip for these strata at this creek.

Grand Gulf formation in Grand Gulf.

The material of the Grand Gulf formation in Grand Gulf is quite variable. Cross-bedded sands pass over and alternate with friable as well as hard sandstones of the same structure and even regular quartzites occur. The clays have different degrees of induration. I did not notice here the laminated clays found in Terry. It may be that these laminated clays occupy the highest horizon of the Grand Gulf formation, above the sandstones which form the top of the strata in Grand Gulf —if the "Grand Gulf formation" is one single formation.

The sandstones enclose silicified trees. Although making a careful search I was unable to detect any shells as such in these strata, but some of the indurated clays, besides traces of lignitized plants, *contain impressions of fresh-water bivalves*, and these cannot be said to be very rare. The most distinct ones which I was able to collect are two casts of *Unio*, each showing both valves. I procured in all casts of at least three species of *Unio*.

Resumé.

1. After studying the literature as well as the field, I do not know any place where Grand Gulf strata can be seen in actual superposition over the Marine Tertiary.

2. There are two places where strata which cannot be distinguished from unquestioned Grand Gulf can be seen actually overlaid by Marine Tertiary. In one of the cases, moreover, there is internal evidence that these strata were dry land or nearly dry land before the Marine Tertiary was deposited upon them.

3. The Grand Gulf formation, at least for its main part, is not a marine formation; it contains fresh-water shells.

4. A thick and extended marine greensand formation with a numerous fauna is found in Eastern Mississippi. It is parallel to the strata immediately below the Claiborne profile. Its fauna is Claibornian, but approaches the Jacksonian.

ART. IV.—*Notes on the Volcanic Rocks of the Republic of Salvador, Central America;* by ARNOLD HAGUE and JOSEPH P. IDDINGS, of the U. S. Geological Survey.

MR. W. A. GOODYEAR, for a long time in the employ of the government of the Republic of Salvador, Central America, as mining engineer and geologist, has recently sent us for examination and comparison a small but interesting collection of volcanic rocks, gathered by himself in the course of his explorations in that country.

Salvador is the smallest of the Central American Republics. It stretches along the shore of the Pacific from the Gulf of Fonseca to the border of Guatemala. Fifteen miles inland from the coast the mountains rise abruptly above the plain, presenting a chain of volcanoes at irregular intervals with a trend about north-78°-west approximately parallel with the ocean. The principal volcanoes in the republic are Apaneca, Izalco, San Salvador, Santa Ana, San Vicente, San Miguel, and Tecapa. None of them reach any great altitude above sea-level, but many have been more or less active within historic times, while the now famous volcano of Izalco has been wholly built up since the occupation of the country by Europeans. Between these isolated cones and to the northward stretch broad table-lands largely made up of volcanic materials cut through by streams running to the ocean. The broad, general features of these volcanoes and their relations to the physical geography of Salvador, have been described with some detail by travelers who have from time to time explored the country. Notably among these may be mentioned geologists Dollfus and Mont-Serrat, who visited Central America by order of the French government in 1864, and published upon their return, in an elaborate volume, the results of their expedition.*

The vast accumulation of volcanic rocks, lavas, pumices and ashes poured out in Central America appear to have been very little investigated by modern methods of research. A few notes, therefore, which we are able to offer may not be without value to those interested in the lithology of volcanic eruptions.

The specimens collected represent recent volcanic flows, the summits of craters, the slopes of the more important volcanoes, the bottom of deep cañons, table lands, mining districts and quarries. While the collection contains no suite from any one locality showing the relations between different varieties of rocks, it is sufficiently full to be considered as typical of the eruptive rocks of the country.

* Voyage dans Guatemala et Salvador. Paris, 1868.

In the collection are rocks showing a wide variation in mineral composition ranging from very basic to highly acidic forms, from those rich in olivine to others carrying an abundance of quartz. They can all be classified under the following heads: basalt, pyroxene-andesite, hornblende-pyroxene-andsite, hornblende-mica-andesite, dacite and possibly rhyolite. Basalt and dacite are better represented in the collection than the other types. Typical hornblende-andesite, augite-andesite and rhyolite are not found among the specimens studied, and the hornblende-mica-andesites are closely connected with the dacite by the presence of small amounts of porphyritic quartz.

Basalt.—These rocks present quite a variety of forms, differing in compactness from dense to vesicular and scoriaceous, from glassy to crystalline. In color they vary from black to dark-gray, sometimes mottled and red. Some are crowded with small porphyritic crystals of feldspar and olivine, while others are nearly free from macroscopic crystals. The same variableness is observed in thin sections, though the majority of the specimens show a fine-grained groundmass, either glassy and microlitic or microcrystalline, composed of plagioclase, augite and magnetite. Glass, when present, is either colorless or brown and globulitic, occasionally the base of the groundmass is quite opaque from the abundant particles of iron oxide which crowd it. The porphyritic crystals which vary in actual and relative amounts are: basic plagioclase, olivine, augite, magnetite and sometimes hypersthene. The plagioclase, which fills many of the basalts in small porphyritic crystals, appears to be of the more basic species and carries much glass and groundmass in minute inclusions. These feldspars specially characterize the basalt thrown out from San Miguel on January 25, 1884, the most important eruption from this volcano in modern times. Since then the volcano has been comparatively quiet, though every year giving signs of activity more or less intense. Similar feldspars occur in the basalt erupted from the crater of Izalco, January 1, 1881. In both rocks the feldspar crystals average 2^{mm} in length. Olivine is in more or less well developed individuals of small size and of the usual form. It occurs in all stages of decomposition, from fresh to wholly decomposed. In most of the specimens it is quite abundant, but decreases gradually to those in which only an occasional individual is found, hypersthene at the same time increasing in amount where the rock is porphyritic, noticeably in the region of Sensuntepeque.

Augite, in imperfect crystals and grains, is much less abundant among the porphyritic crystals than as a constituent of the groundmass. It is pale, yellowish green in thin section, and the larger individuals occasionally enclose olivine besides

the usual inclusions of glass and magnetite. A rhombic pyroxene of light brown color in thin section, with marked pleochroism, green parallel to the *c* axis and light reddish brown at right angles to it, has the same microscopical character as that found in many andesites in the Great Basin and Pacific coast volcanoes, which chemical analysis has shown to be a variety of hypersthene. It is only found in those basalts poor in olivine. Small crystals and irregular grains of magnetite are always present.

The general structure of these basalts is porphyritic, with the porphyritic crystals in greater or less amounts, usually the feldspars are more abundant than the other macroscopic constituents, though in a few instances the olivine is the most prominent. Only in one of the basalts is there an approach to granular structure, and this occurs on the summit of the crater San Miguel; at the same locality also occur several of the most porphyritic and fine-grained varieties.

Pyroxene-Andesite.—These rocks are represented by fewer specimens than the basalts and in general are not in as fresh a condition. They are dark colored rocks, with many small porphyritic feldspars, 2 or 3^{mm} long, and fewer macroscopic pyroxenes. Eighteen thin sections show that in almost every case there is a very fine-grained, holocrystalline groundmass of feldspar, pyroxene and magnetite grains, with a greater or less amount of porphyritic crystals, of which plagioclase is the most abundant. The pyroxene is only in a few instances entirely fresh. In these cases it is seen to be of two varieties, a light green augite and a pleochroic, pale brown, orthorhombic form, which, as already remarked, corresponds in all its microscopical characters to the hypersthene of the Great Basin rocks. The rock from Cerro de Cunchique is a pyroxene-andesite with small amount of olivine; one of the intermediate forms between these andesites and basalt.

Hornblende-Pyroxene-Andesite.—This is represented in the collection by still fewer specimens, mostly pumiceous in character. They are glassy, fresh rocks with porphyritic crystals of feldspar, hornblende and pyroxene. In one specimen from San Sebastian quarry there occur a few scattered grains of crackled quartz, and in rock from the volcano of Ilopango occasional grains of olivine. No mica was observed either in the hand specimens or in thin sections.

The porphyritic feldspars are all plagioclase, apparently in the labradorite-andesine series, with numerous inclusions and other features characteristic of the feldspars of glassy andesite. The hornblende is of a brown color, in some cases with a reddish, in others with a greenish tinge. It is without black border, and in not perfectly developed crystals. The margins

of the larger hornblendes are often filled with grains of pyroxene. The pyroxene, which is less abundant than hornblende, consists of a pleochroic, orthorhombic and a green, monoclinic variety, the former being in excess. Magnetite appears as a regular porphyritic constituent.

The groundmass of the pumiceous varieties is a colorless glass with a few microlites. A holocrystalline form was collected at San Francisco Mercedes.

The most notable occurrence of hornblende-pyroxene-andesite is the rock of the new volcano which first made its appearance above the water in the center of Lake Ilopango on the morning of January 21, 1880. Lake Ilopango measures between nine and ten miles in length, is very irregular in width, presenting about forty square miles of surface. It lies about five miles due east of the City of San Salvador and about 1500 feet above sea-level. Mr. Goodyear, who had been studying the very remarkable series of earthquakes which occurred all over Salvador in December of the preceding year, recorded over six hundred earthquake shocks, all of them sufficiently severe to be perceptible without the use of instruments. On the day following the first eruption Mr. Goodyear* visited the young volcano and brought away with him a piece of the rock still hot from the steam issuing from the numerous vents.

The breaking out of this volcano was generally regarded by the people of San Salvador as having saved the city from a serious calamity.

The rock is a gray pumiceous glass, full of brilliant feldspars, 4 or 5^{mm} and less in length, and numerous small crystals of hornblende with hypersthene and augite, and occasionally a grain of olivine. It is worthy of mention that within a short distance from this outburst of hornblende-pyroxene-andesite, and within twelve months of the time, the volcano Izalco threw out basalt from the crater.

Hornblende-Mica-Andesite.—This type is poorly shown in the collection, only three localities in the Republic being represented. They carry beside the porphyritic crystals of plagioclase, hornblende, hypersthene, and a little augite, variable amounts of brown mica and quartz, and in this way form a transition to the dacites. They resemble some varieties of the hornblende-mica-andesites found at Washoe, Nevada.

Dacite.—Rocks of this type are found in numerous localities throughout Salvador, and present quite a variety of forms. They are mostly light colored in shades of gray and purple, and frequently unite characters both of andesite and rhyolite.

* W. A. Goodyear: Earthquake and Volcanic Phenomena, December, 1879 and January 1880, in the republic of Salvador. Panama, 1880.

Those, characterized by large porphyritic crystals of feldspar and quartz with much mica and hornblende, approach the hornblende-mica-andesites, while those poor in the iron-magnesian silicates closely resemble the rhyolites. In thin section it is seen that the feldspars of those rocks rich in porphyritic crystals are almost wholly triclinic, scarcely an orthotomic feldspar having been recognized among them. The species probably belong to the andesin-oligoclase series. Porphyritic quartz is at the same time abundant in dihexahedral crystals or rounded grains, bearing glass inclusions, frequently with the accompanying phenomena of strain. Biotite occurs in excess of the hornblende, which is often entirely absent. The different varieties of these dacites have their equivalents throughout the Great Basin of Utah and Nevada, especially at Mount Prometheus in the Toyabe Range, and in the Eureka and Washoe mining districts. No well defined rhyolites with characteristic sanidin are found in this suite of rocks, although chemical analysis might possibly show that some of the lithoidal varieties without any well defined mineral constituents more properly belong to rhyolite than dacite.

An examination of this collection shows clearly that the vast accumulation of material poured forth from the volcanoes of the Cordillera of Salvador bears the closest resemblance in composition to the lavas from the volcanoes of the northern Cordillera in California, Oregon, and Washington Territory, notably Mount Shasta, Lassen's Peak, Mount Hood and Mount Ranier.

Moreover a rigid comparative study of these rocks proves clearly the closest similarity between the volcanic lavas of Salvador and those of the Great Basin of Utah and Nevada, both as to macroscopical habitus and microscopical detail. In comparing rocks of corresponding types from the two regions they are seen to carry the same constituent minerals with identical characters in thin section, and the same gradation in mineral composition. Transition rocks from one well-defined type into the next more or less basic or acidic type are sufficiently well represented in Salvador to show the same laws of mineral development as observed in the lavas of the Great Basin.

It is interesting to note that nearly every rock in this collection has its counterpart in Nevada, although there occur many varieties in the latter region not found in the limited series from Central America. This is specially true of rhyolite which covers so large areas in Nevada, but is wanting in this collection. It seems probable that many rhyolitic eruptions may have occurred in Salvador which will be found upon further search.

The resemblance between the volcanic products of the two regions is strikingly brought out by a comparative study of the basalts; in many instances the basalts found in Salvador exhibit an identical structure with those described from the Great Basin.*

The transition from olivine-bearing basalts to hypersthene-bearing andesites is quite the same, and moreover holds equally true for the volcanoes of Oregon, California and Washington Territory.†

Again, the relations shown to exist between the orthorhombic and monoclinic forms of pyroxene in Nevada holds true in the minutest details for the rocks of Salvador. The former yields more readily to the forces of decomposition than the latter, so that many thin sections show fresh augite and partially altered hypersthene, and others unaltered augite with wholly decomposed hypersthene. In no case had the augite been attacked while hypersthene remained unaltered.

The following list of localities includes those from which the better characterized rocks have been collected:

Basalt, from volcano of San Miguel; volcano of Izalco; Carancasuna; Quebrada de San Bartolo; San Ysidro Road; Cerro La Tabla; La Joya, Valle de Zapote.

Pyroxene-andesite, Cerro de Cunchique; Sumpul River, near Llano Malo; Sumpul River, between Oja del Sal and Las Flores; Duron's Mine; Bosque Mine.

Hornblende-pyroxene-andesite, volcano of Ilopango; bank near San Jacinto; San Sebastian Quarry; Cañon of the Tamulasco, below Las Minas.

Hornblende-mica-andesite, quarry, Cerro la Tabla.

Dacite, Cerrito de Avila; Llano de la Haçienda, one mile S.E. of San Ysidro; San Sebastian, columnar rock; Santa Rosa road, three or four miles east of Jocoro; Western Bluff of Cerro La Tabla.

ART. V.—*The Genus Strephochetus:—Distribution and Species;* by HENRY M. SEELY.

1. *Distribution.*—In communicating to this Journal, November, 1885, the existence of the fossil sponge, *Strephochetus ocellatus*, the writer named the towns Addison and Bridport in Vermont and Crown Point in New York as localities where it had been found. Further observation shows the existence of

* F. Zirkel, Microscopical Petrography, Washington, 1876. Hague and Iddings, this Journal, vol. xxvii, June, 1884.

† Hague and Iddings, this Journal, vol. xxvi, Sept., 1883. J. S. Diller, this Journal, vol. xxviii, Oct., 1884.

the fossil over a wide area, while as a constituent of bowlders it has a still wider distribution.

On the New York side of the lake, *S. ocellatus* has been found at Plattsburgh and Chazy. In Vermont it has been observed at Isle La Motte, while the finest displays have been found in the town of Ferrisburgh, at various points, particularly at Ball's Bay just north and at Fields Bay just south of Fort Cassin. At this latter locality surfaces of rock exposing several square feet are crowded with this sponge to the exclusion of every other fossil. Specimens have been gathered at points sixty miles apart, and wherever the middle Chazy occurs, either on the western or eastern side of Lake Champlain, there one may look for *S. ocellatus*. More careful observations are necessary to determine accurately the vertical range of the fossil; probably, however, fifty feet would be a moderate estimate.

2. *Species.*—To the type of the genus *S. ocellatus* there are now to be added three species: *S. Brainerdi*, *S. atratus*, and *S. Richmondensis*.

S. Brainerdi, n. sp.

A free calcareous sponge having the twining canals peculiar to the genus, which structure may enlarge into furrows and further into well-defined cylindrical canals, and these canals may so increase in number and press upon each other that in sections they appear polygonal. The diameter of the large canals varies from $\frac{1}{100}$ to $\frac{1}{250}$ of an inch. The size of this species is greater than any other of the genus yet observed, being frequently over an inch in length. Its outline is usually oval in section, though in many cases the specimens are irregular or angular as though they had been crushed by pressure.

This form has as yet been observed only in some of the magnesian layers intercalated among the compact and fine-grained layers of the Chazy rocks in the magnificent display of these at the village of Chazy, N. Y. The specific name is given in honor of Professor Ezra Brainerd, whose careful observations and accurate measurements have added much to our knowledge of the series.

S. atratus, n. sp.

A free calcareous sponge, smallest of the genus yet recognized, having the external appearance of *S. ocellatus*, with the internal structure of *S. Brainerdi*, the small canals obscure, the larger ones distinct.

This form was obtained from the Black River limestone at McBride's Bay, S. Hero, Vt., and in the Black River limestone at the quarry of west lime kiln, Chazy, N. Y. This little

fossil appears coated with black and from its covering takes its specific name.

S. Richmondensis S. A. Miller.

A free globular or sub-globular calcareous sponge, varying in size from two-eighths to seven-eighths of an inch in section, consisting of numerous irregularly concentric laminæ, separated by interlaminar spaces, filled in most cases with exceedingly small twining canals, or rarely with minute vertical tubes. These laminæ are more dense than the intervening spaces and in those examples in which the tubular structure chiefly prevails they seem the basis from which the tubes radiate. These tubes are arrested by a laminar covering and this becomes the floor for a new set of tubes. This structure of laminæ and tubes may be many times repeated.

The twining canals have the ordinary diameter of the strephochetal structure, about $\frac{1}{300}$ of an inch, the radiating tubes vary from $\frac{1}{700}$ to $\frac{1}{100}$ of an inch; $\frac{1}{200}$ of an inch however is the usual diameter. The irregularly concentric laminæ in cut and weathered specimens give the form the appearance of a Stromatocerium.

This fossil occurs in the upper Hudson River rocks at Richmond, Ind., Madison, Ind., and at Turners, Ky.

The description of the form, *S. Brainerdi*, is hardly complete without further reference to its remarkable structure. While externally it has the stromatoporoid appearance of the other members of the genus, its internal structure may in part vary from the typical form, by the presence of furrows and larger canals, both cylindrical and compressed. One might readily suspect on making a transverse section of some parts of the specimen, that he had in hand a coral, or possibly a coral enveloped by a sponge. But after cutting and carefully examining many sections, and especially as he saw the strephochetal portion at points giving way to furrows, and the gradual introduction of cylindrical canals of large size, and then these, pressing upon each other where the interstitial material became less, until a section was angular, he would reach the conclusion that all these various structures belong really to the same fossil.

S. atratus so nearly resembles *S. ocellatus* externally, that it may be easily mistaken for this latter fossil. Its minute structure however differs from it, and is so obscure, that it was a question whether it could be placed here. Still its general character so nearly resembles the type species, and its structure so closely repeats that of some specimens of *S. Brainerdi*, that it is safe to place it here.

In the paper referred to at the beginning of this article, mention was made of the microscopic character of *Stromatoce-*

rium Richmondense Miller. This form was originally referred to *Stromatocerium* with hesitation, the choice seeming to lie between that and *Stromatopora*. After making many sections it becomes evident that it most nearly approaches the genus *Strephochetus*. Mr. Miller has authorized the specific description above, and it is to be known as *Strephochetus Richmondensis*.

This species has several peculiarities of structure. Not unfrequently it occurs as an incrusting body, having for its core a bit of coral, or a fragment of the shell of a brachiopod. It sometimes resembles the structure of *S. Brainerdi* in the great enlargement of its canals. In this species, however, the tubes present great uniformity of direction though not of size. They run along nearly parallel with each other for a little distance, and then are cut short by a laminar covering which may be the basis for a similar set of slightly radiating tubes. This may be repeated as described in the specific characterization of the fossil, ten or fifteen times.

Sections cut in either direction, horizontal or perpendicular, suggest the genus *Solenopora*, while those of *S. Brainerdi*, in like manner that of *Chætetes*. The discovery of septa or tabulæ, in either of these tubular forms, would lead one at once to place it among the millepore corals. The character of these forms deepens the impression that the line between corals and sponges becomes in some places very narrow and indistinct.

The horizon of these different species is as follows: *S. ocellatus*, near the middle of the Chazy; *S. Brainerdi*, in the upper Dove, higher in the Chazy; *S. atratus*, in the Black River; *S. Richmondensis*, in the Hudson River.

The appearance of the members of the genus may be represented by the smaller fruits, currants, gooseberries and cherries, distributed through a paste of oolitic, fragmental or subcrystalline material. These in most cases have apparently been subjected to pressure and left in a crushed or torn condition. In weathered specimens they show a concentric structure, more or less regular, which is helpful in distinguishing the genus.

There are intimations that the genus exists in rocks higher than those mentioned, and it is quite probable that forms which have hitherto been regarded as concretionary or as pebbles, will on examination be found to belong here. The structure, which for lack of better term, we have called *Strephochetal* will be decisive on this point.

It would be highly satisfactory if it should be found, as is quite probable, that the strephochetal structure always indicates the presence of a sponge. In that case we might by it, hope to settle the question of relationship, now uncertain, of several important genera.

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ART. VI.—*Preliminary Report on the Geology of the Cobscook Bay District, Maine;* by N. S. SHALER.

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PRELIMINARY NOTE.

THE following report gives a portion of the general results of two months exploring work on the shore line of the waters of Cobscook Bay during the summer of 1884. Some previous studies in this district had shown me that it afforded a very interesting field for enquiry and that it would probably furnish data of importance to the general theory of the New England coast geology. I believe the facts set forth in the following pages will justify this opinion, and moreover will show that this field contains a more interesting assemblage of phenomena than can be found on any other part of the eastern seaboard of the United States.

The United States Coast Survey has not yet mapped this district; there is indeed no chart in existence which shows with any approach to accuracy the shore line of these waters. The sketch map accompanying this report was compiled in the main from the British admiralty chart, with some additions from observations made during my summer work. This admiralty map is extremely imperfect, many minor bays, which have no value to the navigator are entirely omitted. At least ten miles of the shore line being unrepresented on that chart.

Owing to this lack of a satisfactory basis on which to record the geology of the district it has been necessary to make this report in a preliminary form. Within two years the Coast Survey topographical parties will have entered on this field and in a few years thereafter it is probable that the shore line will be so far delineated that the geological facts described generally in the following pages though left unindicated on the map, can be properly set forth.

Although, as I have recently learned, some of the fossils at Shackford head have found their way into cabinets and the fossils near Dennyville have been collected by Dr. John Shehan, a student of the geology of that neighborhood, I am not aware that there has been anything published concerning them. The collections which I made, though affording about one hundred species of fossils in a fair state of preservation, can be greatly increased by further research. It has therefore not seemed advisable to undertake a careful determination of the specimens in hand. The species have been identified only so far as was necessary to secure an approximate determination of the age of the more important fossiliferous sections.

The portion of the report which concerns the glacial and surface geology and also that describing the metalliferous veins of this district is omitted in this memoir and will be published elsewhere.

Topography of the Cobscook District.

The topography of any district is the key to its geological structure. This is especially the case with an ocean shore, for there the action of the waves and tides removes the detrital materials which often obscure the bed rocks of inland districts. A reference to a general map of the eastern coast line of the United States will show that this shore from New York northward has the general topographical form proper to the fjord zone or glaciated shore line of high latitudes.

The shore is intersected by deep inlets which extend far into the land. Although these inlets have been to a considerable extent effaced by the formation of salt marshes and other deposits they are still a very conspicuous feature of this district, separating it widely from other coast lines where glaciation has not worked in moulding the land. As will appear from the evidence hereafter to be advanced in this report, the fjord structure, at least along this shore, is the result of the glacial wearing, acting upon a surface of rock of varied hardness.

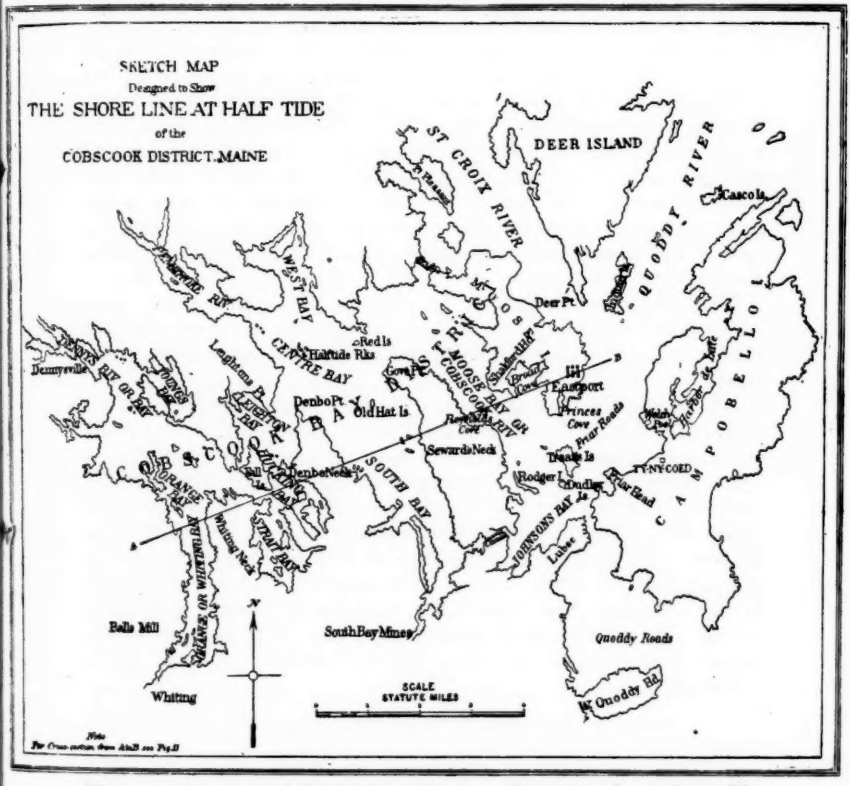
Within this glacial or fjord zone of the Eastern United States we may notice several distinct varieties in the shape and character of these inlets. Along the shore north of Long Island Sound and as far east as Cape Cod the inlets are relatively far apart; their mouths are separated from each other by considerable lengths of tolerably straight shore line. Along this southern shore of New England the axes of the inlets lie nearly in the north and south line. The inlets themselves have few islands in their basins, and are in most cases relatively narrow.

From Cape Cod to Cape Elizabeth, the inlets or fjords are fewer in number and have a general east and west trend; islands are rare and, when existing, are usually composed of drift materials. The relative rarity of inlets on this part of the coast is doubtless to be attributed to the general north and south trend of this part of the shore; its trend being approximately parallel to the direction in which the glacial ice moved.

East of Cape Elizabeth the shore trends in a direction nearly at right angles to the course in which glacier flowed. Here the fjord structure is seen in its fullest development: all of the shore line is in fact made up of these inlets. The extent of the indentation may be the better appreciated by the fact that while the direct line from Cape Elizabeth to Eastport is only

about two hundred miles in length, the length of the shore line, between those points, at high tide, including the coast line of the adjacent islands, probably exceeds three thousand miles.

Along this coast region of Maine we find a considerable variety in the type of fjord structure. About Portland, within the district of Casco Bay, there are no deep inlets but a profusion of small islands. From that bay to the Penobscot the strip-like fjord type of shore, narrow bays with equally narrow promontories, is the prevailing feature. At Mt. Desert the massive crystalline rocks of that region cause the coast to change its character; the bays or inlets become wider and there is an extensive fringe of islands south of the main shore.



The normal type of fjords is again found on the shore from Mt. Desert to Quoddy Head; this section differing in no important topographical respect from that between Portland and the Penobscot.

Cobscook Bay, which is a branch of Passamaquoddy Bay lying north of Quoddy Head, differs from all the other fjord systems of the United States coast in certain important features. As will be seen from the sketch map the system of fjords known by the general name of Cobscook Bay have a curiously embayed nature; all the other similarly extensive fjords of this coast communicate directly with the sea by their southern extremities, but in Cobscook Bay there are many inlets of considerable length which discharge their waters through east and west channels into each other and into the waters of Passamaquoddy Bay. It will be seen that this system of bays has three main divisions to which I have given the provisional names of Moose Bay, Center Bay and Orange Bay. This innovation in the way of names is made necessary by the fact that there are no accepted designations for these divisions though they have great topographical importance.

The general trend of these bays differs considerably from that of the other inlets of the coast. The Cobscook bays have a general northwest and southeast axis, while the other bays of this region are usually inclined a little to the east of north and west of south. In fact the Cobscook system of bays is the only system of inlets on this coast where the major axes of the basins so closely coincide with the direction of the glacial movement.

The system of bays has the further peculiarity that their borders are remarkably intersected by smaller indentations; the whole forming one of the most complicated shore lines in the world.

These peculiarities of outline indicate local differences in the bed rocks on which the glacial sheet has acted. They are sufficiently accented to make it clear to anyone who has had a little training in the interpretation of topography, that this district is occupied by rocks having a different character from those that form the other portions of the New England coast. It was indeed these peculiarities of outline that led me to begin my detailed study of the New England coast at this point. It seemed clear that there must be some important geological causes for the abnormal geography. As will be seen in the sequel this opinion has been amply justified by the results obtained.

Geology of the bed rocks of the Cobscook district.

The geology of the bed rocks of this district presents certain remarkable peculiarities. Those rocks consist of a very thick series of stratified deposits of Paleozoic and perhaps Azoic age intermingled with numerous sheets of igneous rocks which are partly intruded and partly interbedded deposits, the latter in

the main apparently composed of true lavas but at certain points evidently composed of fragmental volcanic rock in the form of ash beds and breccias. In their composition, in their attitude and in their fossil contents they present many eminent peculiarities.

In the absence of any sufficient topographical survey of the district it has not been found possible to prepare a geological map which will represent even the more important features of this structure.

The following account is intended only to present the more general facts which were determinable by a preliminary inspection of the ground.

The first point that strikes the observer is that the exposures of rocks of Silurian and Devonian age which are shown in the Cobscook district, i. e. the region lying to the east of Moose Island, have nearly uniformly eastern dips. The following table of these dips will show that in localities fairly representing about one hundred miles of shore line in the Cobscook series of bays, there is very little departure from this uniform direction. It is also evident that the amount of this dip is not great and is very regular; it rarely rises above 60° and rarely falls below 20° of inclination. The few instances in which the dip of the rocks departs decidedly from the general easterly direction may be explained by local accident and do not indicate any general change in the direction of the dip. It should be said that the dips given in the table represent about the average of over two hundred observations from which the selection was made.

Selected list of dips observed in Cobscook Bay.

Locality.	Strike.	Dip.
McMaster's Island	N. 45° E.	S.E. 10–60°
Eastport Island, W. side	N. 45 W.	N.E. 60.
" " " "	N. 60 E.	N.W. 20.
Reynolds Cove	N.	E. 20–30.
Pembroke River	N. 10 W.	N.E. 30.
Pembroke Neck, W. side	N.	E. 20–30.
" " E. "	N. 125 E.	S. 17.
" " " "	N. 110 E.	S.E. 10.
Dudley Island	N.	E. 50–60.
Pembroke River	N. 45 W.	N.E. 55.
" "	N. 45	N.E. 45.
" "	N. 130 E.	S.E. 30.
South of Seward's neck canal	N.E. to N.W.	E. 10–30.
South Bay	N. 50 E.	E. 30–40.
" "	N. 45 W.	E. 15–25.
Straight Bay	N. 40 W.	E. 35.
" "	N. 40 W.	E. 35.

Locality.	Strike.	Dip.
Near Dennysville	N.W.	E. 15–30°.
Near Denbo Point	N. 10 W.	E. 42.
" " "	N.	E. 45.
" Bay	N. 15 W.	E. 10–30.
" "	N.W.	E. 22.
" "	N. 90 E.	S. 15–30.
" "	N.	E. 35.
" "	N.	E. 20–35.
" "	N.	E. 32.
" "	N.	E. 25–30.
" "	N. 40 E.	E. 40.
Pembroke River	E. & W.	N. 20–30.
" "	N. 45 E.	S.E. 20–40.
" "	N.	E. 20.
Johnston's Bay	N.	E. 30–50.
Shore	N. 45 W.	E. 30–50.
Fall Island	N. 45 W.	E. 28.
Orange Bay	N.	E. 50.
" "	N. 30 W.	E. 20.
" "	N.	E. 30–40.

At many points the igneous rocks which seem to be interbedded among the stratified deposits may be seen in what appear to be massive strata, often a hundred feet or more in thickness, having the same general dip as the rocks between which they lie. At no points are the upper and lower contacts of these igneous masses and the stratified beds clearly enough seen, or at least well enough studied, to make it possible to determine the question whether they were injected between the beds or were contemporaneous deposits.

The igneous rocks of this district may be divided into three classes: 1st. Detrital igneous rocks, those which are composed of fragmentary materials which have fallen through the air. 2d. What seem to be true lavas, i. e. those which have flowed over the superficial rocks. 3d. Dykes which traverse, strike or penetrate between previously existing beds of sedimentary or igneous origin.

1.

Diagramatic section of shore 1½ miles N.W. of Red Island. Length 300 ft. A, greenish diorite. B, greenish and gray flags and slates, with obscure fossils. C, high tide line.

The distinctly fragmental deposits, volcanic ashes in general character, are most abundantly exhibited in that part of Cobscook Bay which forms the channel immediately to the west-

ward of Moose or Eastport Island. This series of ash beds covers a considerable area; in this part of the district the beds have the average dip of the rocks in the region and though their upper and lower contacts with the series of fossil-bearing beds is not well determined there can be little doubt that they are a constituent member of the Paleozoic section.

The best exhibition of these volcanic ash deposits is at McMaster's Island, a small peninsula about midway of the western side of Moose Island. This little island, of only a few acres in area, is almost altogether composed of beds of a fragmental nature. At first sight and from a little distance these beds closely resemble coarse gravel and conglomerates; but, on closer inspection they are seen to be made of fragments mostly angular, which though lying in regular beds have their major axis at all angles to the horizon; moreover, the larger bits which exceed a foot in diameter have evidently fallen with a certain violence into their places as is shown by their crushed form. All these fragments seem to be composed of volcanic or crystalline rocks, among them are many bits of pumiceous material which is rarely so vesicular as to deserve the name of pumice but distinctly related to that class of volcanic products. The evidence derived from the section at McMaster's Island and from the other exposures in the vicinity show that the set of volcanic beds exceeds five hundred feet in thickness and may be far thicker. It is likely from the width of its glacial trail in the region to the southward that this series of rocks occupies a good deal of the space of the channel known as Moose river.

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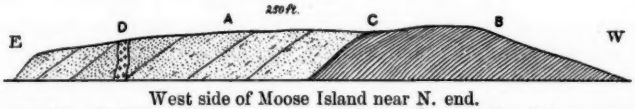

West side of Moose Island near N. end.
A, greenish ash beds. B, green siliceous flags. C, contact—obscure—apparently overlie. D, red felsite dyke 20 ft. wide.

The evidence goes to show that this series of McMaster's Island was formed some time before the Hamilton period. It seems clearly overlaid by the extensive series of the Shackford Head group and the equivalent beds of the Princes Cove section, while its base appears to rest upon the rocks which are probably of Silurian age.

There are some other points in the Cobscook section whose rocks of the same general structure as those of McMaster's Island are exhibited. The other exposures may or may not be of the same age as those before described. They probably represent several stages of volcanic eruption at various periods in the Silurian age.

It appears from the distribution of these contemporaneous deposits of volcanic nature that the center of eruption was to the northeastward of this district and that the intensity of its effects diminished toward the southwest. There is some reason to believe that this field of volcanic material is the

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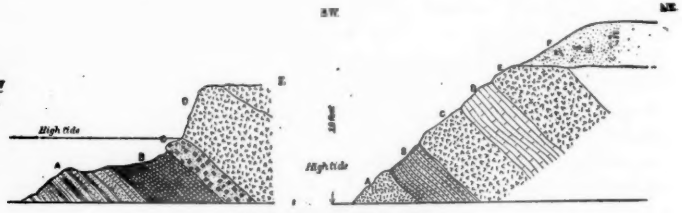

Sections on Deny's River.

Fig. 3.—A, stratified volcanic ash. B, dark colored shales. C, ash beds as before. D, fragmental trap.

Fig. 4.—A, volcanic breccia. B, shales. C, felsite. D, indurated sandstone. E, banded felsite. F, drift.

extension of the ash-bed district which is known to occur near St. Johns, New Brunswick. The preliminary study of this Cobscook district has sufficed to show that in about this same horizon there are very extensive sheets of lava which were possibly surface flows, though afterwards buried beneath subsequently formed deposits. Of these the most important is a great mass of reddish felsite which occupies a wide field in the northern part of Moose Island and probably extends beneath the bays in this neighborhood. Besides this extensive sheet there is another, of the same general character, seen in the hill crowned by the old earthwork fort near the middle of Moose Island. The latter sheet of felsite is apparently interbedded in slates of Silurian age.

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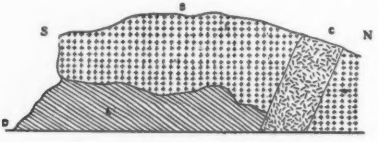


Section on shore N. of Red Island.

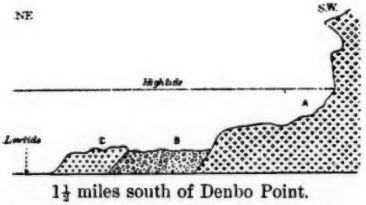
A, gray slabs and flags. B, greenish diorite. C, red felsite. D, high tide mark.

The felsites of this region also appear in dykes having a general north and south trend, which traverse all the other formations of this district; being perhaps the latest intrusions

which have taken place. These dykes are most extensively developed in the northern part of the Cobscook district, especially in the area about McMaster's Island and in the region to the westward as far as Deny's River. The felsites are, as is well known, found in the region about Lynn in Massachusetts. The Cobscook felsites do not however exhibit the same distinct flow lines as those from the more southern localities. They have not been observed in the clearly banded or ribboned form which they often exhibit in the region near Boston.

Besides these extensive extrusions of lavas belonging to the group of felsite porphyries, there is a larger series of other dyke stones and sheet lavas which exhibit a very great variety of appearance. Some of them are of a blackish, slaggy aspect, showing a tolerably distinct bedding, which seems to arise from successive flows. The best exhibition of these slaggy lavas is at the cape known locally as Denbo Point, the extremity of which is formed by them.

6.



1½ miles south of Denbo Point.

A, greenish mottled trap. B, metamorphosed conglomerate. C, greenish amygdaloidal trap.

Besides the above mentioned lavas there are many other varieties of igneous rocks found in this district which are not classifiable by ordinary microscopic characters. These resemble in their general aspect the ordinary dykes of eastern New England. The classification of all these volcanic products must be left until they can be submitted to a careful lithological study.

The rocks of Silurian age are so cut up by these various intrusions that not more than one-third of the whole land area intersected by the arms of Cobscook Bay, is occupied by these strata. It seems likely that the sedimentary Paleozoic strata are extensively developed beneath the surface of the bays, the intervening ridges of land being occupied in the main by the harder volcanic rocks. That this is the case, is well shown by the fact that the stratified Paleozoic rocks are generally found as a fringe along the shores of the long, narrow capes which divide this bay into many inlets. These Paleozoic rocks are

clearly less resisting to the glacial action than those of igneous origin; they are not only softer, but their thin-bedded and much-jointed condition caused them to break up under the action of the ice or waves much more readily than the compact igneous deposits.

7. Diagramatic section from mainland to Moose Island, near Eastport, along line A, B, of sketch map. A, A, A, stratified rocks, probably all Silurian. B, Devonian. C, intruded crystalline rocks.

The greater part of these sedimentary rocks of the Cobscook series consist of very fine grained sandstones, and dark blue and blackish shales, which at certain points contain a good deal of lime, but rarely are pure limestones. At only two or three points are these beds sufficiently calcareous to be used in making commercial lime, and even at the best of these points, as in the beds exposed in Reynolds Cove, an effort to use them for lime failed, for the reason that in the greater part of the rock there was so much silex that it was apt to melt in the kiln. The siliceous element in the rock is larger than in any equally extensive section of these horizons known to me in this country, though at few points does it consist of pebbly matter; the only important exception being in certain conglomerates of a reddish color, apparently belonging to about the horizon of the Medina sandstone. These beds have so far been found only in or near the basin known as Mine Cove, an inlet near the head of great South Bay of Cobscook Bay. At many other points there are strata which contain small scattered fragments of hypogene rocks, presumably volcanic in their origin. These are particularly well shown in the extensive limestone section exposed at the head of Denbo Bay, the shallow fjord lying to the west of Leighton's Point.

The fossiliferous rocks of the Cobscook district are mostly thin-bedded, even the impure limestones, though sometimes appearing in massive form, being on the whole distinctly divided into strata of no great thickness. The general absence of detrital material derived from the land, as well as the nature of the organic contents of these rocks of the Cobscook series, favor the hypothesis that they were formed at some distance from the shore. It is generally

believed that the deep sea deposits have more continuity of structure, i. e., are less divided into layers, than those found near the shore. This is probably the case with the strata formed in many parts of the sea; still we know that the Devonian black

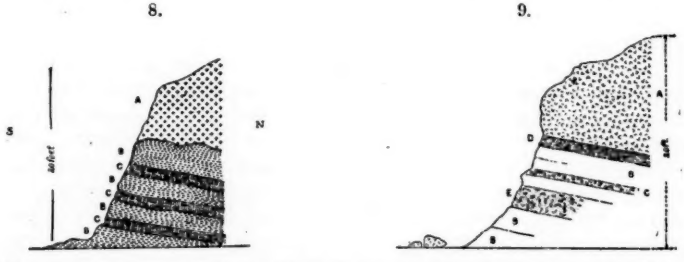


Fig. 8.—Section on Pembroke River, Cobscook Bay. A, massive trap 30 ft. thick. B, B, B, sandstones and shales. C, C, C, thin ash beds.
Fig. 9—Section 3 miles N.W. of Red Island. A, massive trap. B, B, red sandstone and shale. C, breccia, probably volcanic. D, irregular ash bed. E, vermiform concretions in sandstone (Scolithus tubes).

shales of the Ohio Valley termed in the Kentucky reports the Ohio shale, have a remarkable amount of stratification planes, though they were certainly formed in deep water in a position remote from the shore. We also know that any such disturbance as would be produced in the deep seas by an earthquake shock, would certainly cause a movement of the mud of the sea floor, thereby bringing about the formation of a stratification plane in the deposit. As this region was much subjected to volcanic action at the period when these sediments were depositing, we may well believe that earthquakes were common in this portion of the sea floor.

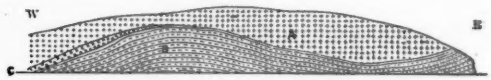
The great preponderance of siliceous and shaly beds and the remarkable absence of limestones in this district is a noteworthy feature. It is probably due in the main to the singular absence of corals and the infrequency of brachiopods and crinoids, which groups were the principal lime producers of the Paleozoic seas.

All the evidence goes to show that these rocks of the Cobscook series were in the main formed in water of moderate depth under circumstances, which, owing to some causes, were not very favorable to the development of organic life. In the latter regard this district is in striking contrast with the basin of the St. Lawrence, where during the same periods the seas contained a singularly abundant life, as is shown by the Upper Silurian deposits of the Island of Anticosti. I venture to suggest, as a possible cause of this peculiarity, the fact, that this

portion of the old sea, in which the fossils of the Cobscook section lived, was on the northeastern face of the old Appalachian Island, and thus by their position were cut off from the warm current which flowed from the southwest against the ancient shores of Central New York. This same life-giving current of warm water may have found its way along the western shores of the Appalachian island to the region of the St. Lawrence.

The action of the mountain-building forces on these sedimentary deposits of Cobscook Bay has been great but extremely peculiar in its effects. Everywhere within the field of my enquiry there are evidences of much pressure, except perhaps in the southern part of Whiting or Orange Bay; that the rocks have been subjected to strong compressive action, is shown by the general distortion of the fossils. This distortion is very general; it is doubtful if in any part of the basin the rocks have entirely escaped it. The amount of the distortion varies from an elongation which does not exceed one-twelfth of the diameter to a very extreme condition, where it is as much as one-half the diameter of the distorted object, i. e. where a circle of an inch in diameter lying in the plane of the movement would be changed to an ellipse having a length of an inch and a half. Possibly one of the results of this compression is the singularly close adhesion of the fossils and the matrix. In the many thousand specimens of fossils observed, none were found fairly separated from the rock in which they were preserved. The pressure seems to have welded the walls of the fossil to the matrix in a very perfect manner.

10.



Shales and trap south end of Shakford Head.
A, overlying trap. B, dark colored shales. C, intrusive trap.

The most curious feature in the attitudes of these rocks is, that few of their dislocations take the form of folds, only three examples of folding meet the eye, in the hundred and fifty miles of cliffs inspected. (These exceptional folds are shown in figs. 10, 11 and 12.) In nearly all cases the dislocations were effected by a system of principal faults extending in a general north-northeast and south-southwest direction, cut more or less nearly at right angles by less important transverse fractures.

So far none of these fractures, except in a few unimportant cases, have been observed in the form of simple faults; they seem in nearly all cases to have been made the pathway for extrusions of igneous matter thrown out at the time when the

faulting occurred. This fact seems to indicate that the source of supply of this volcanic material was very near the level of the rocks, so that no fissure of any size could form without giving exit to igneous matter. This may perhaps be explained by the

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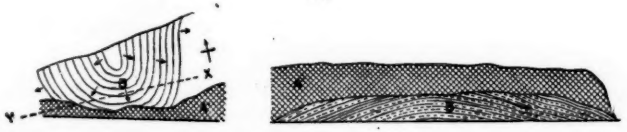
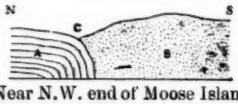


Horizontal and vertical section of small fold on shore 2½ miles N.W. of Red Island. A, A, trappean rocks. B, B, reddish and greenish shales. X—Y, line of section 200 ft. long.

fact that the rocks of this region were very near the seat of extensive and long continued volcanic action which naturally led to the formation of a very large supply of rock matter in the state to be forced into every crevice which penetrated to it.

The almost invariable dip toward the east and southeast exhibited by the masses of stratified rocks in this district is a very remarkable feature in its structure, one for which I have no explanation to offer.

12.



Near N.W. end of Moose Island. A, hard flaggy slates. B, volcanic ash. C, slickensided contact.

Extending our observations beyond the shores of Cobscook Bay, we find in the shores of Passamaquoddy Bay a considerable change of structure. The islands of Campobello and Deer Island have the general structure of anticlinals, the basin between them, known as Quoddy river, being distinctly synclinal in structure. These islands are in the main composed of a series of very compact and highly metamorphosed, non-fossiliferous schists, slates, and quartzites considerably cut by dykes, which in the main apparently belong to an older series of extrusions than those which intersect the fossiliferous rocks. These rocks, which for convenience may be termed the Campobello series, are clearly several thousand feet in thickness. They have disclosed no fossils, although a careful search has been made for them. An assistant of the present writer, Mr. G. H. Squier, a very acute observer, spent several months in a detailed study of the geology of the island of Campobello without finding the least trace of fossils in the abundantly exposed beds. The entire absence of limestones, or beds of a calcareous nature, is sufficient to show that they cannot be regarded as the metamorphosed equivalents of the Cobscook series. The general absence of lime from this Campobello series is

shown by the fact that there is very little calcareous matter in the numerous veins which are found in the rocks of this series.

13.

Ideal section through Deer Island anticlinal.

A, A, Campobello series. B, B, sandstones and conglomerates: Perry series?

It will be observed from the diagramatic section showing the general geological character of Campobello and Deer Island, that they are only obscurely anticlinal in structure; being, in fact, rather complicated upheavals of intermingled stratified rocks and igneous intrusions. After they had been elevated above the sea and much eroded an extensive series of sandstones and comglomerates, which are essentially like the ordinary rocks of the Perry section were deposited upon their flanks, or possibly over the whole of the Deer Island. A further development of these axes, together with much subsequent erosion, has caused the Perry beds to appear only in the downfold between these two anticlinals.

If the Cobscook series existed on the flanks of Deer Island and Campobello, as was almost certainly the case, its beds had been eroded before the Perry series of conglomerates was laid down.

It will require much further study to unravel the succession of upheavals and subsidences which have taken place during the deposition of these rocks. There is, however, the promise of abundant reward for this enquiry, for it may throw very important light upon the history of the development of this continent.

As yet the Campobello series has not been identified in place immediately below the Cobscook series. But at various points it is seen in positions which make it a fair inference that it underlies the whole of this district. On the cape known as Quoddy Head the Campobello series is well shown in a highly metamorphosed condition. This series is traceable for three miles to the westward; indications of it were found in the region to the west of Denys River with dips which would take it beneath the Cobscook series.

In the further search along this coast for the beds of the Cobscook series, it will be well for the observer to bear in mind the fact that the Cobscook series probably lies immediately upon the more ancient beds of the Campobello series. The series of rocks exposed on Campobello is probably well developed along the coast of Maine. Rocks essentially simi-

lar in appearance to those on Campobello abound about Frenchman's Bay, and at other points to the westward. Wherever these rocks occur it seems to me there is reason to hope for some traces of the overlying Cobscook series.

One of the most difficult problems in the section is to determine the relations of the Perry series of sandstones and conglomerates to that of Cobscook Bay; at no point as yet has the former series been found in contact with the latter. But in the valley of Sipps Bay we find a series of red shales and sandstones, which has a thickness of over fifteen hundred feet, and probably belongs to the Perry series. These beds have the same general dip as those of the Cobscook series, where the latter series is shown about a mile farther to the south. It is likely that a careful search in this part of the field may reveal a contact of these two sets of beds.

On the mainland just north of Moose Island, and thence up to the town of Perry, similar sandstone and conglomerate beds are shown, with a strike which would place them above the beds of the Cobscook series of that island. But in this Perry district the section of red shales and sandstones lies apparently on the denuded edges of the granitic and syenitic rocks which form a yet lower series than those which furnish the floor of the red conglomerates and shales of Deer Island. That is to say, while the Perry series of Deer Island lies on the old slates of the Campobello series, in the more northern exhibition of the beds they are directly on the rocks of presumably Laurentian age. The Perry series of rocks appears to be much less cut up by dykes than the underlying Cobscook series; no intrusions of igneous matter were observed in the outcrops which were studied. This makes it probable that the time of most intense volcanic action had passed away before the Perry series was deposited.

Thus this district seems to contain the following more or less well indicated series of stratified rocks. At the base a series whose thickness is unknown, consisting of gneissoid syenitic and granitic rocks and some mica schists; of this series little is known: it is the prevailing series of crystalline rocks along the coast of Maine, and is probably of Laurentian age.

Above these series lies a second which for convenience we have termed the Campobello group, comprising a set of dark greenish and grayish siliceous and argillaceous rocks containing very little lime.

This Campobello series has a thickness of at least four thousand feet and may be thicker; the rocks appear to be entirely destitute of fossils though they are not so much metamorphosed as necessarily to lose by this change all trace of fossils if they had once contained them. This section may be equivalent to

the slates of the Cambridge district in Massachusetts, and generally of the Cambrian slates about Boston, which they resemble in a general way, especially in the remarkable absence of lime in their composition. This Campobello series probably rests immediately on the subjacent older series of Laurentian age, and may represent the lower Cambrian section, but the phenomena of contact with the underlying beds are unknown. Above these Cambrian layers, and without observed contacts with them but with scant place for any intermediate deposits, lie the beds of the Cobscook series. This series has a thickness in all of not less than four thousand feet, and on careful study may be found to have much more than this depth. Although the contact between this series and the Campobello group is not known, the facts justify us in saying that an extensive elevation and erosion of the last named deposits took place before the deposition of the Cobscook series was begun or after they were formed, for they were not present on the Deer Island anticlinal or on the banks of the St. Croix river, where the Perry series was laid down. The presumption is that they were originally in place on these surfaces, but were worn away during the interval between the close of the Cobscook series and the formation of the Perry beds.

Last in this succession of deposits we have the coarse red sandstones, conglomerates and reddish shales of the Perry series. This deposit is certainly over two thousand feet in thickness. It differs very widely from those which occupy a lower level in this district; nearly all the other deposits seen are mainly if not entirely made up of materials such as may be laid down in a tolerably deep sea. The Perry section was clearly formed in shallow water in immediate proximity to the land.

If the lower part of the section at Perry should turn out to be upper Devonian or Sub-carboniferous, as seems not improbable, then the evidence will be to the effect that a period of erosion occurred in the interval between the close of the middle Devonian section and the formation of the Perry beds. This is especially interesting, as it would seem to show that this portion of the continent was above the sea during a part of the Devonian, or of the Sub-carboniferous period. Moreover, the character of the sediments which formed the Perry series favors this view. Those are clearly materials which were derived from neighboring lands. If we could assume with Sir A. C. Ramsay that all such red sandstones as are found in the Perry section were formed in fresh or brackish water, then this series would perhaps indicate a time when the shore line was at or near its present position. This view is rendered quite probable by the fact that the Perry beds have yielded a certain number of land

plants, and so far has furnished no trace of fossils which could have been formed in marine deposits. I do not propose at present to consider the age of the Perry series, as the problem is one of peculiar difficulty and requires a much more extended study than I have been able to give to it.

We shall see in the subjoined account of the fossils from several horizons of the Cobscook series that what appear to be the uppermost beds of that series contain an assemblage of forms which belong in the Devonian section. These fossils are in a very thick section of blackish slates resembling in certain features the Devonian black shales of the Mississippi valley and the basin of the great lakes. These beds, like their presumed western equivalents, probably were deposited in the waters of a deep sea at a considerable distance from the main land, yet in a time that cannot be very far separated from these Moose Island shales, as I have termed the black shales of this series. The Perry sandstones were deposited in conditions that show that they were made on the mainland or in an estuary basin. Thus the elevation which followed the deep subsidence occurring in the time of the Moose Island black shale, appears to have brought this part of the continent above the sea level, while in the Ohio basin it only served to shallow the water and bring the shore nearer than it was before.*

Although these conclusions as to the divisions of the rocks in the regions near Eastport must be subject to review after a more thorough knowledge of this district is attained, they are sufficient to show that the oscillation of levels of this district and the data attainable from the composition of the sediment, will afford some important clues to the geological history of the continent. It should be said that these divisions of the rocks in and about the Cobscook district are presented with much hesitancy; although it may be found in the end to be extremely imperfect, it will at least serve as a basis on which to build a more critical study of the rocks of this region.

Fossiliferous Horizons of the Cobscook series.

We turn now to the problems connected with the stratigraphic equivalency of the various divisions of the Cobscook series. It has also been noticed that the very great amount of igneous injections and the extensive erosion to which this district has been subjected has made it very difficult to determine the stratigraphical relations of the fragmentary sections which remain. This problem is still further complicated by the difficulty which is found in using the fossils contained in the rocks

* It may be incidentally suggested that the conglomerates and sandstones of the Perry series should be compared with the deposits of the Catskill period of the Hudson district.

as data for the identification of their age. Of the hundred or so species of fossils which have already been approximately determined, the greater part are either distinctly unlike those obtained elsewhere, or belong to forms which have a wide vertical range in the rocks of other districts. A number of the most interesting forms are so far novel that they offer no evidence of value as to the age of the beds in which they occur. Moreover, judging from the other known deposits of middle Paleozoic age on the Atlantic slope, those of Newfoundland, New Brunswick, and Nova Scotia, the typical divisions of the New York section or of the Mississippi valley, do not retain their limits on the eastern shore of the continent. The Silurian deposit of Anticosti cannot be precisely paralleled with those of the interior basin and much the same lack of definite relation to the western section is found in all the horizons which are represented on the Atlantic coast basins. This difficulty is one which might fairly be expected. The faunal divisions in contemporaneous strata of the Paleozoic rock though less clearly marked were hardly less numerous than those of the present day, i. e., the faunal areas whether determined by the difference between deep sea and shallow water, or by the difference between the sides of a barrier such as separated the Paleozoic deposits of the continental basin from the Atlantic coast were as numerous as those in the existing seas.

Although these divisions were nearly as distinct in the Paleozoic era as found at the present time, there was, it is true, no such delimitation of zoological or botanical provinces as at present; no such difference as those which now separate the Australian from the American province existed in the Paleozoic time, but the lesser differences of faunal divisions, though not so much accented, were something like as numerous as at present. It is therefore by no means surprising that we find difficulty in determining the relations between the deposits of the Cobscook series and those of the typical western series of the continent.

The Cobscook series presents us with the several sets of beds which in their physical characters and their organic contents seem to indicate separate horizons. By far the richest horizon yet found in this series is that which is shown on the west side of Orange or Whiting Bay about half a mile south of Ball's Mill. At this point the fossiliferous strata are seen with a thickness of about twenty feet. On the west they are cut off by an extensive series of dykes and in the east they dip below the level of the bay.

These beds are only exposed below high tide mark which fact made collecting in the few hours on two days when the

locality was visited, very difficult. The rock is a very dense, much jointed, siliceous limestone; the fossils are less distorted than any others yet found in this basin. They appear on the fracture faces of the rock with great clearness of outline and are extremely abundant. From about five hundred pounds of material selected from the upper ten feet of this section, careful dissection with hammer and chisel developed the fifty or more species from which the position of the group has been preliminarily determined. It is probable from the results obtained that at least one hundred species may be obtained from this point. The next most important locality which is as a horizon to be separated from the Orange Bay section is that exposed in Denbo or Leighton's Bay, about two miles to the northwest of Denbo Point.

This locality exhibits at least two hundred feet of shales and impure limestones. These beds are barren of fossils in the lower parts, but in the upper hundred feet contain about thirty species of fairly well preserved fossils. At this point the beds are much distorted, the fossils having an average elongation of one-fourth their original measurements. The strata are much softer and thinner bedded than those of the preceding section, to which is perhaps due their greater distortion from pressure. None of the species from this and the preceding locality are precisely identical, though there are certain species common to the two localities which are closely allied to each other.

The third locality which gives hopes that it may prove the basis for a separate horizon is that shown about one mile northeast of Dennysville. As yet this locality has been imperfectly studied: the beds appear some distance below the water line in very solid ledges which will require a considerable use of powder before they will freely yield their fossil contents. The small amount of material gathered seems to indicate that the deposits are closely related to those of the Orange Bay section, but probably represent a separate and inferior horizon.

On the eastern shore of Seward's Neck near the north end of Roger Island, and again at Reynolds' Cove, there are considerable exposures of compact, thick-bedded limestone which distinctly differ in their general aspect from the other horizons of the series; there are only a few species of fossils in this section and these are very imperfectly preserved.

On the Denbo shore, i. e., the western shore of Great South Bay at about one and one-half miles south of Denbo Point, there is a locality exhibiting very massive beds of limestone having a rich brachiopodal fauna. The contained fossils have been very much modified by pressure, being very greatly extended in the northeast and southwest axes. The outcrop of these strata consist of singularly smooth "roches moutonées," from which

only small quantities of the rock could be detached. The fossils promise to afford a series very nearly connected with those in Leighton's Bay and probably of the same age but representing a different association of fossils. On the west shore of Straight Bay there is another set of rocks affording a section over one hundred feet in thickness containing a limited but peculiar fauna.

The last of these important sections is that exhibited on Moose Island, on which Eastport stands. This consists in a great thickness of shales of a generally dark carbonaceous look, reminding the observer, as has already been remarked, of the Devonian black shale of the Ohio valley and western New York.

The Moose Island series is rather thicker bedded than the ordinary Devonian shale; its upper part is composed of dark, siliceous flags, with occasional interbeddings of what will probably prove to be volcanic ash deposits. The section as a whole is decidedly like the Devonian black shale. The series, as far as exhibited, has a thickness of about one thousand to fifteen hundred feet, but neither its superior or inferior limits are seen.

The Orange Bay section, being that which is richest in its fossil contents may, in the determination of these various horizons advantageously be used as a datum level. If its stratigraphic position can be approximately determined, the other sections can then be grouped about it. This seems a more feasible way of approaching the problem than by trying to make separate identifications for each section in the basin.

The following list of fossils from this last named horizon, with the comments given therewith, will serve to show the data which are now in hand for determining the geological age of the beds.

List of Species.

Mollusca.

Orthoceras perstriatum.
" tenui-annulatum.
Holopea antiqua, var.
Platystoma depressum.
Platyceras lamellosum.?
" platystomum, var.
Loxonema allied to L. Fitchii.
Anatina sinuata?
Avicula allied to A. manticula.
" " A. securiformis.
" " A. communis.
Megambonia allied to M. lata.
" " M. ovata.
Spirifer modestus?
" perlammelosus.

Spirifer cyclopterus ?
" octocostatus.
Rhynchonella mutabilis.
" abrupta.
" vellicata, var.
" formosa.
Rhychonella æquivalvis, var.
Rennselæria allied to R. ovalis (doubtful).
Leptocœlia allied to L. fimbriata.
" " L. concava.
Atrypa reticularis (extremely abundant.)
Orthis pedunculosa, var.
" planoconvexa, var.
Strophodonta planulata, var.
" Beckii, var.
Trematospira allied to T. Deweyi.

Articulata.

Dalmanites closely allied to D. micrurus.
Tentaculites irregularis, var.

In this and the following lists of species no revision of the generic and specific names has been attempted.

The thirty-three species of fossils which are named in the preceding list, have been in the main determined from casts of the exterior or interior, of the shells or other hard parts; this being the form in which the remains are commonly preserved in the beds of this locality. The species from the equivalent New York strata have generally been described and figured from specimens which show the substance of the hard parts. Any one who has undertaken identifications under these circumstances, must have remarked the difficulties involved in such comparisons. Despite these hindrances to complete determination, the identification may perhaps be taken as sufficiently accurate to serve the needs of the problem in hand.

There can be little doubt that these species prove the beds from which they came to be, in a general way, the equivalent to the Lower Helderberg group of New York, but it does not seem possible, at least at present, to refer the deposit to any particular division of that series of beds. It should also be noticed that there remain at least twenty species of fossils from this locality, which are as yet unidentified many of which may hereafter be found to belong to other geological horizons; moreover nothing like a complete collection of the fossils contained in the deposit has yet been secured.

Although the species given in the above list are in most cases closely related to the forms to which they have been referred, it must not, for the reason before given, be assumed

that complete specific identities have been proved; that degree of accuracy in the determination cannot be secured until much more extensive comparisons are made.

It should be noticed that there are many genera of fossils which are commonly represented in the deposits of Lower Helderberg age, which have not as yet been found in this series of rocks. So far the abundant collections have shown no Lingulas, no distinct Meristas, no Nucleospiras, no Trematospiras, no Leptænas of the *L. depressa* type and very few species of the genus Orthis. There is scarcely a trace of corals or crinoids; no Bryozoa have been found.

The next locality of importance is that near Dent's Point, at the head of what is locally known as Leighton's Cove. The physical character of the rocks differs considerably from that of the Orange Bay deposits, before described. The Leighton's Cove series consists in the main of shales generally thin-bedded and containing but little lime. About two hundred feet in thickness of beds is exposed, but of this only the upper half is fossiliferous. The fossils are well preserved, but have been subjected to a considerable distortion from pressure; the elongation being in a general northeast and southwest direction. Thirty species have been found in these beds, of which the following have been approximately determined.

List of Species.

Dalmanites limulurus. Clinton.
Beyrichia symmetrica. Niagara.
Orthoceras imbricatum.
Orthis allied to O. elegantula } as usual these two forms blend
" O. hybrida } together. Niagara.
Atrypa cuneata, var. Niagara.
Chonetes allied to C. cornuta, but much larger and with finer ridges. Clinton.
Orbicula squamiformis, var. Niagara.
Lingula oblata. Clinton.
Avicula allied to A. textilis. Lower Helderberg.
" emacerata. Niagara.
" rhomboidea. Clinton.
Modiolopsis sublatus. Niagara.
" ovatus, var. Clinton.
Orthonota curta, var. "
Cyclonema ventricosa. "
Murchisonia subulata. "

The greater part of these species are represented by abundant but poorly preserved specimens. Although the identifications are not perfectly satisfactory, they serve to show the relation of these beds to the horizons of the Clinton and

Niagara in New York. The dozen or more, less well determined forms, the names of which are not given in this list, probably belong in the same series of strata.

As the collections made at this locality came from about one hundred feet in thickness of beds and contain several thousand specimens, they may fairly be taken to represent the general nature of the life of the Clinton and Niagara epochs in the sea of this region. It is interesting to note the fact that several very important and elsewhere abundant genera and families of animals are not represented here. Not a trace of a coral and no bryozoan has been found in the collection. Crinoids are extremely rare and are represented by a few small fragments of stems. Among the Brachiopoda the Strophomenas are represented by only one obscure species, and the characteristic Strophodontas do not appear; the genus Orthis is very scantily represented. The most abundant group in number of species is that of the Lamellibranchiata.

So far not one of the species in this locality has proved to be clearly identical with those collected at the previously described locality in Orange Bay, but it is not impossible that among the undetermined forms some species common to both may be found.

The next set of beds in order of importance, which permit of approximate identification, are those which are exposed at a point about one mile northeast of Dennysville. These beds are scantily exposed in the belt below the high tide level, where they appear in the form of low glacially worn ridges. The specimens collected from this locality probably represent in a very inadequate way the fauna found in the rocks.

The total number of species collected is about twenty, of which the following are approximately identified.

List of Species.

Pleurotomaria percarinata, var. Trenton.
Atrypa nitida, var. Niagara.
" aprinis, var. Niagara.
Spirifer crispus, } not distinctly separable. Niagara.
" bilobus. }
Syringopora multicaulus? Niagara.
Heliolites spinipora. Niagara.

All the unidentified forms from the preceding locality seem to be related to Niagara species. Thus, as far as this limited evidence goes, these beds are to be taken as belonging to the Niagara limestone, or at least having a close relation to the beds of that horizon.

By far the most important section of the paleozoic series of rocks as regards its thickness or its geological significance

which is exhibited in this district is that which is found on the western side of Moose or Eastport Island. As before noted I propose to term this section the Moose Island series for the reason that the beds are most abundantly developed on that island, it being indeed doubtful if they occur elsewhere in this district. These deposits consist mainly of black and dark gray shales and slates. They are exhibited at several points along the western shore of Moose Island from north of Shackford Head to near Eastport. The total thickness of the section is not known as neither its superior nor its inferior limits are disclosed. It is evident, however, that at least one thousand or one thousand five hundred feet of beds are shown in the several exposures, or indicated as in existence between the outcrops.

The dark color and the shaly nature of these beds will remind any one familiar with the aspect of the Devonian shales of Western New York and the Ohio Valley; the deposit which has been termed the Ohio shale in the Reports of the Kentucky Survey. Although fossils abound at Shackford Head and Princess Cove, they belong to few species and are not very well preserved, having been somewhat distorted by the considerable pressure to which the beds have been subjected. The following species are fairly recognizable.

List of Species.

Modiomorpha, allied to M. subulata.
" sp. undetermined.
Murchisonia desiderata.?
Beyrichia, species not determined.
Lingula, a species not determined.
Discina, two species.

The total number of species recognizable in the large collections made at this point does not exceed ten, though the individuals amount to many thousand. Though these forms taken alone afford slender ground for identification of the deposits, still they are entirely consistent with the supposition that the series is equivalent to the Ohio shale.

It is much in favor of this view that the beds occupy a position where we might fairly expect to find the Devonian series of rocks. Thus though it is not safe to affirm that this series belongs to the Ohio shale it is undoubtedly the most reasonable supposition that can be applied to the facts.

If it should in the end be found that these beds represent the great Devonian shale it will add a new interest to that remarkable deposit: so far this series of the Ohio shale has not been clearly traced in the section east of the central Appalachian axis. If these beds at Eastport belong to the Devonian

shale it had an extension to the east which must carry it beneath the Atlantic Ocean. The exact determination of the age of these beds is one of the most interesting matters for future research afforded by the geology of the Cobscook region.

Besides the above mentioned localities where organic remains have been found there are many others, a score or more in number, scattered along the great length of shore of this region, which to my preliminary study yielded too few and altogether too imperfect fossils to make it profitable to undertake the determination of their age. It seems possible that among these beds there may be found traces of the fauna of the lower Silurian, especially of the Trenton and Hudson River groups. If these faunæ are represented at all, it is clear that they are shown in a very imperfect manner, still the search has as yet been so inadequate that much may yet reward the careful explorer. There is reason to believe that these fossil-bearing Cobscook rocks extend much farther to the west than they have yet been followed. It is also probable that they may be found considerably to the north of the points where my explorations were carried.

From the foregoing summary of my observations in this region it will be seen that it affords a large field for profitable study. It seems likely that at least three hundred species of fossils may be gathered from the localities exposed along the cliffs of the Cobscook fjord system, many of them are undescribed forms, and in all cases they depart in an interesting manner from the types found elsewhere.

The problems now are to compare these species with those from the classical localities of New York and elsewhere, so as to determine how far the horizons accepted in those regions may be recognized in the Cobscook district. This task cannot well be undertaken until the topographic representation of this district is on a satisfactory basis. Such is the complexity of the topography as well as of the geological accidents that nothing in the way of final work can be done until a good map is secured. As the parties of the United States Coast Survey expect to be working in this region in 1887 we may hope to have the basis for a good map before 1890, it may be well to postpone the delineation of the geology until that time. In the meanwhile the more important parts of the geological work, all that relates to the assimilation of the deposits to those of other districts, can be carried on.

It seems to me that it will be well to extend the search for the beds of the Cobscook series to the shore line both to the east and west of the region treated of in this preliminary report. It is not likely that they have been preserved on this portion of the shore alone. Their general character shows that

with the exception of the Perry beds they were deep sea deposits and therefore presumably covered all this part of the coast. They may fairly be expected to appear both in the southern part of New Brunswick and along the Maine shore to the westward.

It is particularly important that they should be sought for elsewhere for the reason that in the Cobscook series it is evident that not one-twentieth part of the total fossiliferous section is revealed. The greater portion is completely covered by the extruded rocks, or is buried beneath the glacial drift, or is hidden by the waters of the bay. If the beds are found elsewhere there is reason to hope that these hidden portions of the section may there be exposed to view. In this way we may hope to complete the stratigraphic as well as the paleontological series of the district.

Nearly every exposure of fossiliferous strata which occurs in this region manifestly owes its preservation from glacial and other wear, which would have eroded the beds to below the sea level or removed them altogether, to the protection afforded by the dense and erosion-resisting covering of lava which lies upon it, or has only recently been worn away. This points to the conclusion that in searching for these deposits in the neighboring parts of the coast it will be well to examine every point where stratified rocks appear beneath the cliffs of igneous rock; such being the position in which these relatively soft beds are most likely to have survived the destructive effects of glacial and marine erosion, both of which causes have acted with peculiar energy along this shore.

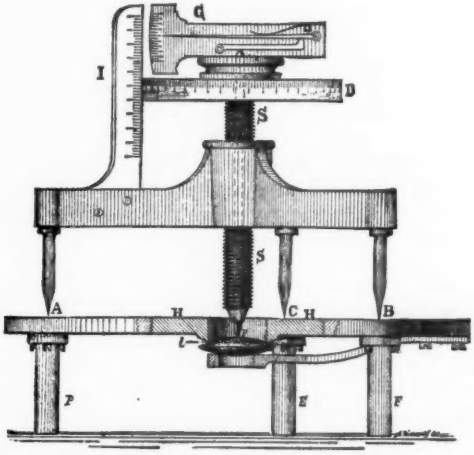
It should be borne in mind that these fossiliferous horizons have an especial interest from the light they may throw on the position of the shore line in past times. Therefore not only the organic remains which they contain but also the detrital matter of which the rocks are formed is of much importance. The occurrence of a conglomerate apparently of the Clinton or Niagara age in the section on the western shores of South Bay seems to show that the shore in this district was not far away during a portion of the time when the Cobscook series was forming. The general character of the pebbles in this bed indicates that the ancient shore was composed of the hypogene rocks, syenites, etc., which now constitute the principal materials exposed to erosion in this part of the continent. Again in the age of the Perry section we have evidence that the shore line was near its present position and that the rocks exposed to erosion were principally of Laurentian age. Thus it is evident that we may reasonably hope, from the study of this field, to find our way to conclusions of great value to American geology.

ART. VII.—*On the Well-Spherometer; an instrument that measures the radius of curvature of a lens of any linear aperture;* by ALFRED M. MAYER, Professor in the Stevens Institute of Technology, Hoboken, New Jersey.

DURING the past ten years I have used in my laboratory a spherometer that gives measures from which we can compute the radii of curvature of lenses of very small linear aperture. This instrument I exhibited, and its mode of use I explained before the National Academy of Sciences on Nov. 15th, 1882. The spherometer, as generally made, cannot measure the radii of lenses of small diameter, by reason of the large spread of the feet of the tripod that support the micrometer screw. On some spherometers these feet are made to slide toward the screw till they are equidistant from it, and so near to it, that they can stand on the surface of the small lens whose radius is to be measured. The objections to this arrangement are: (1) that when the feet are thus brought near the screw the instrument is top-heavy, and it becomes difficult to determine nicely the contact of the point of the micrometer screw; (2) that it requires expensive workmanship to make these slides carry the feet so that the plane passing through their points shall remain at right angles to the axis of the screw; (3) the difficulty of adjusting these feet so that they are equidistant from the axis of the screw; (4) the difficulty of measuring what is known as "the radius of the instrument;" i. e. the distance of *the points of contact* of the feet from the point of contact of the screw. This objection (4) applies to all spherometers except the one described in this paper. The necessary curvature of the terminal points of the tripod renders the radius of the circle, including these points of contact, variable with the radius of lens; and these points of contact cannot be determined with precision except by difficult measurements on the form of the points and subsequent troublesome computations; and then both the zero reading of the screw and the radius of the instrument are changed from what they were when referred to a plane surface. It has been attempted to overcome this objection by making the points exceedingly fine; but in this condition they are soon blunted by use and deformed by the least carelessness. (5) To be able to bring the feet of the tripod sufficiently near the axis of the screw to measure lenses of very small diameter, these feet have to be made very delicate and the screw has to be terminated by a long pointed rod; thus making the feet liable to spread from the weight of the instrument pressing them upon a curved surface of small radius.

The instrument which I now describe is, I think, free from these objections and has, in my practice with it, given accurate results.

1.



The points of the tripod A, B, C, fig. 1, rest on a plane surface. A disc of steel H, H, is screwed into the plate of the instrument, this disc has a cylindrical aperture, or well, accurately formed. The surface of the mouth *l*, *l*, of this well is turned to a sharp edge by a hard tool with a sharp and properly formed cutting edge.

To measure the radius of a lens, a steel disc is selected whose aperture is smaller than the diameter of the lens, and it is screwed firmly into the plate. A piece of flat glass is now pressed by a spring against the lower opening of the steel cylinder, and the reading of the head of the screw is taken when the pressure of the point of the screw on the glass plate makes the contact-lever, G, read zero. The flat plate is now replaced by the lens, D, and the screw is approximately centered in the steel well. The screw head is turned till the contact-lever reads zero, then the spherometer is slid over the top of the lens till the contact-lever gives the highest reading, the axis of the screw then coincides with the axis of the well, and is in line with a radius of that portion of the lens contained above the plane passing through the mouth of the well. The instrument, now stationary, is adjusted till the contact-lever reads zero. The difference of this reading and the one obtained when the screw was in contact with the plane surface gives the height of the section of the lens above the plane of the bottom of the well.

The interior diameter of the cylinder is found by accurate measures with vernier-calipers, or by measures with a dividing engine furnished with a micrometer-microscope. Then the formula $R=\frac{r^2}{2h}+\frac{h}{2}$ gives the required radius. R=radius o lens; r=radius of interior of well; h=versed sine of radius of lens, or, height of section of lens above edge of bottom of cylinder.

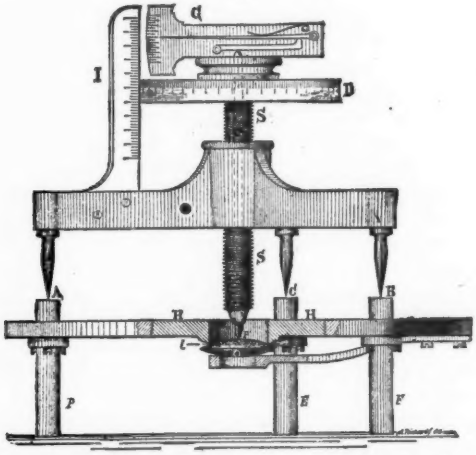
When the radius of a concave spherical surface is to be measured, the outside edge of the cylinder is used. The diameter of this cylinder can be very accurately measured. The same cylinder may do for measurements on either concave or convex surfaces if its outside and inside edges are made by a plane perpendicular to the axis of the cylinder. This form of cylinder I have generally used. Four or five of these of different diameters will be sufficient for most work. The interior diameters, I have selected are ·2, ·35, ·6, 1·00, and 1·7 inches; or, in millimeters, say, 5, 9, 15, 25, and 40·5. The thickness of the cylinders are about $\frac{1}{16}$ in. or, $1{\cdot}5^{mm}$.

In the account of the measures with this instrument it has been assumed that the tripod of the spherometer rests on a plane surface and also that the plane of the bottom of the well is parallel to this surface. It is not difficult, now that Brashear has reduced to practice the elimination of the errors of an approximate plane, shown by the most delicate test which applies itself to the whole plane at once (namely, the interference bands produced by reflection from the surface of the plane required and the surface of a true plane of glass resting on it), to obtain planes whose departure from truth is less than the indication of the best spherometer. In the planes I use, one of glass, the other of steel, my spherometer, by Brünner, of Paris, does not show a departure from a true plane of $\frac{1}{125000}$ of an inch. These planes, however, when being made were not tested by the optical method. The parallelism of the plane closing the bottom of the well and the plane on which the spherometer rests is, of course, given by the spherometer itself if this be an *instrument of precision*. This it only is when furnished with the means of getting contact by the intervention of a lever, level, or the electric-contact. Every instrument of precision contains in itself the means for its adjustment and for the determination of its errors of measurement. If when the spherometer is brought to the zero reading and the screw is moved over the plane forming the bottom of the well, this adjustment remains in all positions of the screw on the plane, then the two planes are parallel. Any want of parallelism can be detected to $\frac{1}{125000}$ inch. I state this quantity so as to be within bounds; for from nine settings of the Brünner spherometer I found that the extreme

+ or − departure of single measures from the mean of the nine is only $\frac{1}{125000}$ inch.'

In one spherometer, which I have, fig. 2, the axis of the screw is made so that it coincides with the axis of the well. In this

2.



instrument two of its feet rest in conical holes; the third foot in a V cut in the direction of a line joining this foot with the axis of the well. Any want of parallelism between the planes cannot be determined in this form of apparatus. If this error exist it has to be computed and allowed for; and for this we have to know the inclination of the planes. This can be measured, in the other forms of spherometers described, by several optical methods. If the plane at the bottom of the well should be tilted 1°, which is an inclination far beyond that which would be made by any one honestly calling himself a skilled mechanic, the error in the measurement from the true height of the section of a lens of 2 in. radius and ·2 in. thickness would equal +·000027 inch. This error is however difficult to compute and is not susceptible of a simple expression in terms of the inclination of the planes and of the radii of lens and well.

If x = the true height of section of lens above bottom of well;
a = measure really made, at an angle to plane of bottom of well;
θ = angle formed by the two planes of the spherometer;
r = radius of curvature of lens;

$$x = a\cos\theta + \frac{a^2}{2r}\sin^2\theta + \frac{a^4}{8r^3}\sin^4\theta + \text{etc. or,}$$

$$x = a\left(1 - \frac{\theta^2}{2} + \frac{\theta^4}{24} - \text{etc.}\right) + \frac{a^2}{2r}\left(\theta - \frac{\theta^4}{3} + \frac{\theta^6}{30}\right) + \frac{a^4}{8r^3}\left(\theta^4 - \frac{2\theta^6}{3}\right) \text{ or,}$$

$$x = \cdot 99984760d + \cdot 000152284\frac{d^2}{r} + \cdot 00000012\frac{a^4}{r^3}$$

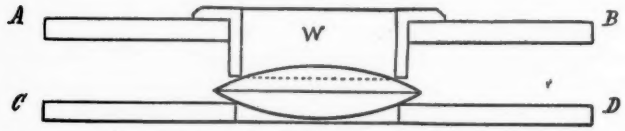
It is better to use the spherometer of the form given in fig. 1, and to bring the planes to true parallelism; which can be accomplished by placing thin foil under the flange of H, H (not shown in the figure). This tilts the axis of the well so much from its previous position that the instrument retains its zero reading when the screw is moved over the plane at the bottom of the well.

The contact-lever on the Brünner spherometer differs from that shown in the figure. The lower end of a delicate contact-lever is bent at right angles and at the angle of this short arm of the lever is the fulcrum. At the other end of this short arm is a point at right angles to it. A delicate spring constantly presses this short arm of the lever downward. The point on the short horizontal arm of the lever is the contact-point used in making measures. This delicate lever is carried on a piece of metal which slides in a guide attached to a horizontal arm of the tripod. The ends of this piece of metal are bent at right angles, and between these are embraced the screw. The lower end of the screw rests in a conical hole in the bent arm, and a set-screw enters a conical hole in the upper end of the screw. On the longer and vertical arm of the contact-lever is a lug on which is engraved a fine line. When this line is made to coincide with a line, drawn on a standard, the screw is at zero of contact. The coincidence of the lines is obtained by means of a microscope attached to the instrument.

Mode of measurement with the well and the ordinary spherometer.—The ordinary spherometer is simply a tripod, supporting a nut N in which runs a screw P. The head of the screw is divided into fractions of a revolution, and the pitches of the screw are read on a vertical scale attached to one of the legs of the tripod. The zero reading of this apparatus is obtained when the four points, those of the tripod and that of the screw, are in the same plane. The most accurate way of getting this adjustment is to place the plane on the top of a resonant box and to run the screw down till it lifts slightly two of the feet of the tripod above the plane. Then, on quickly and gently tapping the plate a rattle will be caused by the instrument vibrating about the screw-point, which is its highest point of support. If the screw be run slightly upward this rattle will become just audible and then, on a very small amount of rotation of the screw, it disappears. The reading of the screw may now be taken for the zero-reading. If this reading is obtained by an upward motion of the screw then all subsequent measures referred to this one should be made by contacts obtained by the same direction of motion; otherwise, the "back-lash" of the screw will enter to vitiate the measures. I have found that contacts on a large plate can

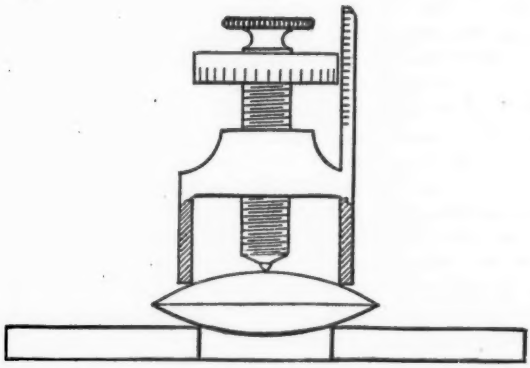
be obtained by this rattling-test to $\frac{1}{10000}$th of an inch. It must not be inferred, however, that other contacts, like those on the top of a small lens, or on a small and thin plate, can be determined with the same accuracy. The very test requires vibration and unsteadiness in the instrument; and these conditions are not those for precise work. This ordinary spherometer cannot, in my opinion, be regarded as an instrument of precision, like the lever-contact spherometer.

3.



In measuring radii of lenses with the ordinary spherometer we use a plate A, B, fig. 3, with a hole in its center. In this hole is cemented the steel well W, whose lower opening rests on another plate. This rests on the resonant box. Parallelism of the surface at the bottom of the well and that of A, B, on which stands the spherometer, is determined by the rattling test. If this parallelism of the plates does not exist, it must be obtained by re-cementing the well with thin foil placed under the flange of the well. This cement is not placed under this flange, but only on the outside of the cylinder of the well. In attaining the height of the section of the lens (shown in dotted lines in fig. 3), it is best to rest this in a hole

4.



in a plate C, D, placed on the resonant box, and then place the plate with the well on top of the lens. Small corks may be placed between the plates to prevent too much motion of the well around the spherical surface of the lens.

Simple forms of Spherometers with which the well is used.—Other and simpler forms of the well-spherometer suggest themselves. They may be worth the recording, as they may be considered useful by those desiring only approximate measures with simple and inexpensive apparatus.

Fig. 4 shows a form in which the tripod is replaced by a hollow cylinder carrying in its axis a micrometer-screw. The figure explains itself. The micrometer-screw may be replaced by a graduated rod sliding along a fixed vernier, or, a rod may be used without graduation, and two marks cut on it by a sharp edge drawn along the upper surface of the top of the cylinder. One of these marks is made when the point of the sliding-rod touches a plane closing the bottom of the cylinder; the other when the rod rests on the spherical, or other surface, to be measured. The distance separating the marks thus made is then measured with a micrometer-microscope.

Fig. 5 shows how the common micrometer-screw calipers can be used to determine the radius of curvature. With it we measure the united thickness of the well w and the plate p, cemented to its top. Call this measure t. Then we measure the thickness of the lens; call this l. Then the lens covers the bottom of the well, and the thickness of well and plate and lens is measured in this position. Call this t'. Then $(t+l)-t'=$ height of section of lens above plane of mouth of well. If the axes of screw and well coincide, the pressure of the micrometer on the lens tends to center it in the well. If the plate covering the well be rigid, and the pressures in all the measures be made as equably and as gently as possible, one can thus get the height of the section of the lens to $\frac{1}{1000}$th of an inch. The same measures can be made with the vernier-calipers.

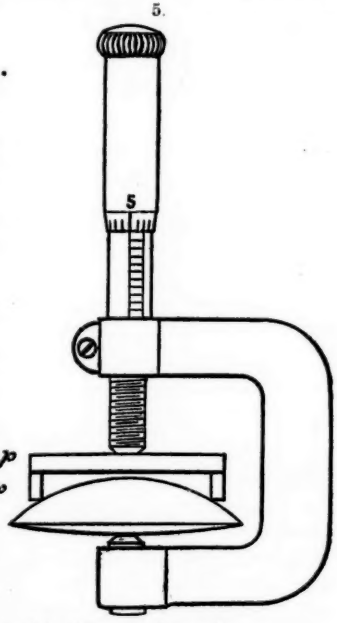
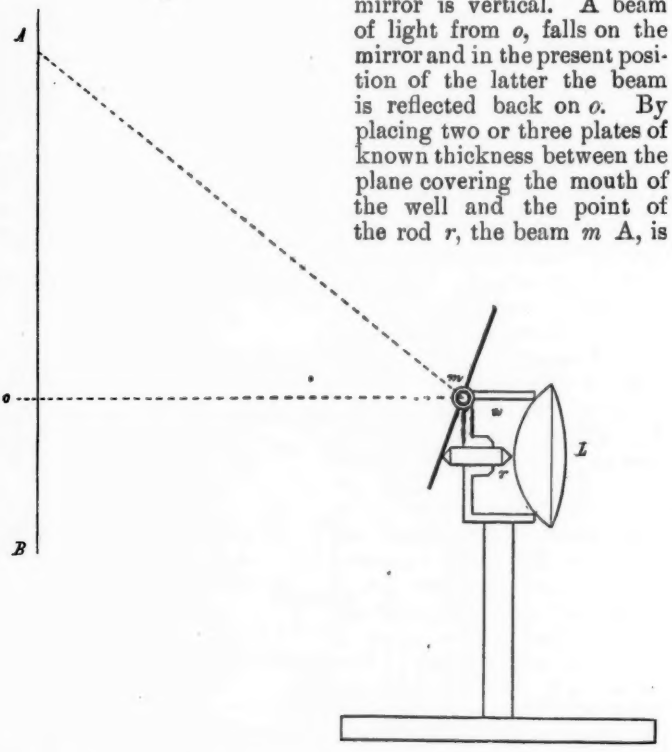


Fig. 6 shows a simple optical method in which the well is used. The well W, is placed with the plane of its mouth vertical. The well is attached to a stand whose base is firmly screwed to the table. A rod, r, slides neatly through a hole in

the plate closing the back of the well. Hinged to the top of the back of the well is a mirror *m*, and this is pressed against the point of the rod *r*, by a delicate helical spring. When the point of the rod *r*, touches a plane which closes the mouth of the well, the plane of the mirror is vertical. A beam of light from *o*, falls on the mirror and in the present position of the latter the beam is reflected back on *o*. By placing two or three plates of known thickness between the plane covering the mouth of the well and the point of the rod *r*, the beam *m* A, is

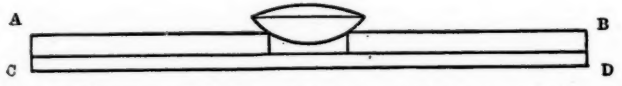
6.



reflected upward on a vertical scale A, B. The linear values on this scale of equal parts may be determined from these measures. The tilt of the mirror can be measured by observing in a telescope, placed on the line *o m*, the reflection of the scale from the mirror *m*. The amount of motion of the rod against the mirror is as the tangent of the angle of rotation of the mirror, and the reflected beam moves over a space equal to twice its horizontal distance from the screen into the tangent of angle of tilt of the mirror. It is evident that the height of the section of the lens, L, contained within the mouth of the well can thus be measured.

Fig. 7 shows how, with a compound microscope, having its fine adjustment screw furnished with a micrometer-head, we can measure with a well of small diameter the radii of curvature of very small lenses. A, B, is the plate with the well of small diameter. This plate rests on another plate, C, D, with a fine scratch on its upper surface, in the center of the bottom of the well. We first place a piece of thin glass, with a fine line on it, on the top of A, B, with the surface carrying the line

7.



resting on the top of A, B, and focus on this line and then take the reading of the screw-head. This plate is then removed and we focus on the line at the bottom of the well, and again take the reading. The difference of readings gives us the depth of the well. Then the lens, which has a fine mark on it where its principal axis cuts its surface, is placed on the glass plate C, D, and the microscope is focussed on the fine mark on the top of the lens, and the reading of the screw taken. The lens is now removed and the microscope is focussed on the fine line on C, D, and the reading of screw is taken. The difference of these readings gives the thickness of the lens. The lens is now placed, as shown in figure 7, covering the top of the well. The line on the top of the lens is again focussed and the reading taken. Then the lens is removed and the microscope is focussed on the line at the bottom of the well, and the screw-head reading taken. Call this measure t'; the depth of the well t, and the thickness of the lens l. Then $(t+l)-t'=$ the depth of the section of the lens below the top of well; and as the radius of well is known, we can compute the radius of the lens.

ART. VIII.—*On some general terms applied to Metamorphism, and to the Porphyritic Structure of Rocks;* by JAMES D. DANA.

A. METAMORPHISM.*

THE ordinary methods of metamorphic change recognized in geology are the following:

(1) The development of a crystalline condition in the original materials; recently shown by Törnebohm, Sorby, Irving and

* The terms applied to metamorphism are considered in the Presidential Address of Professor T. G. Bonney before the Geological Society of London, in February last; but the copy of the address did not reach the author until June 22, when this paper was just going to press. It does not call for any change in the remarks here offered.

Van Hise to be a development of the grains into crystals or larger crystalline grains by external additions made conformably to the crystallographic axes of the original grains.

2. A change from one paramorphic state to another: as from augite to hornblende, from aragonite to calcite, etc.

3. A change through chemical transformation: as that of chrysolite and other species to serpentine; a portion of a dolomite with included or intruded silica to tremolite, etc.

The last of these methods has been styled *metasomatic* (signifying change in *body*) to distinguish it from change under the first method, to which the word *metamorphic* is accordingly restricted. But this new term is not specific as to *kind* of change; and it applies as well to the second method. A term expressing the *chemical* nature of the change is desirable, and such a descriptive term is *metachemic*. Substituting this we may have the following three descriptive terms for the three methods of metamorphism: I. The *Crystallinic;* II. the *Paramorphic;* III. the *Metachemic*.

Messrs. King and Rowney, some years since, applied the term *methylosis* (meaning change *in substance*), with the adjective *methylotic*, to chemical metamorphism. But metachemic is more simple and intelligible; and priority can put in no claim against a change for the better where such terms are concerned.

By the above scheme, we have the term *metamorphism* as the general title, instead of giving it up to the first method. Each of the three methods involves change in *form*. Paramorphic change is, eminently and specifically, change in form; and metachemic is at least as much so, though complicated with change of other kinds; while change by the first method involves the minimum amount, since, as we now know, the original crystallization remains unaltered, and is only built upon after its own laws. Moreover, the first and third processes,—the most unlike,—are essentially one in agency; the alkaline siliceous waters that build out a quartz crystal, sufficing in some cases (consecutively, if not simultaneously) to convert feldspar into mica, and make other chemical transformations. A common name for the whole is demanded; and *metamorphism* has the necessary comprehensiveness and flexibility in signification and also in its usage in other departments.

In a case of metamorphism, two of the processes of change have often gone on at once, if not the three. For example: the 1st and 3d have worked together in making a tremolitic dolomite; so also in making a mica schist, in which, as proved by Van Hise in his excellent paper (last volume of this Journal) the mica is largely or wholly derived from feldspar, while the quartz grains become enlarged by the 1st method; the 2d and 3d, in the change of an augitic rock to a hornblendic,

whenever iron oxide or other ingredient is at the same time set free, as has often happened, this indicating that a change in constitution accompanied the paramorphic; the 1st and 2d, in the metamorphism of a common limestone to a crystalline limestone (calcite), supposing such a limestone to be (as it usually is) partly aragonite; and so on. In the derivation of a hornblendic rock from a sedimentary rock, the metamorphism would ordinarily be *metachemic;* but if from an augitic rock, paramorphic in part if not wholly.*

B. Porphyritic Structure.

Petrography has such names as *felsite-porphyry*, *diabase-porphyry*, *quartz-porphyry*, *augite-porphyry*, etc.; the first two, and others like them, implying that the rocks named are *porphyritic* with crystals of some kind of feldspar; the third, that *some* kind of rock is porphyritic with crystals of quartz; the fourth that some kind of rock is porphyritic with crystals of augite. It has also the name *orthophyre*, for a porphyritic rock having orthoclase in crystals; *augitophyre*, as an equivalent of augite-porphyry; and so on.

It is now generally admitted that the porphyritic character is of trivial value in petrography; that it marks off only *varieties*, and therefore cannot, in any right scientific system, be the name of a group of rocks. For the designation of varieties its recognition is important. Moreover, for this purpose, the precise feldspar or other mineral that constitutes the crystals should be indicated in the qualifying term. The following words, based in plan on such terms as *orthophyre*, *augitophyre* and the like, may well be applied to porphyritic varieties, whatever the kind of rock:

Orthophyric,	when the crystals are		Orthoclase.
Oligophyric,	"	"	Oligoclase.
Labradophyric,	"	"	Labradorite.
Anorthophyric,	"	"	Anorthite.
Leucitophyric,	"	"	Leucite.
Nephelophyric,	"	"	Nephelite.
Augitophyric,	"	"	Augite.
Chrysophyric,	"	"	Chrysolite (Olivine.)
Quartzophyric,	"	"	Quartz.

Granite, gneiss, mica schist, syenyte, felsyte, trachyte, rhyolyte, obsidian, are often *orthophyric*; felsyte, rhyolyte, dioryte,

* The terms *metapepsis* and *paroptesis* have been proposed by Mr. Kinahan of Ireland for, respectively, "regional" and "contact" metamorphism. *Contact* is an objectionable word; but *local* is good; for it includes changes due to heated emanations and other conditions where there are no contacts. *Regional* and *local* describe the conditions well, and have been used for a dozen years at least in this country; and why we need go to the Greek for two words is not clear.

dacyte are often *quartzophyric;* in addition to true augite rocks, trachyte, andesite, etc., are sometimes *augitophyric;* different diabases or dolerytes and basalts are *labradophyric, anorthophyric, augitophyric* or *chrysophyric*; and the same specimen is often both augitophyric and chrysophyric, and sometimes also labradophyric. In a similar way *sphærophyric* may be applied to a crystalline rock containing spherulites or concretions of any kind, distinguishing the structure, thus, from concretionary by concentric deposition, or that common in uncrystalline rocks.

This list of adjectives can be extended if precision in the description of rocks requires it.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

1. *On a new Absolute Electrometer.*—Bichat and Blondlot have presented to the French Academy a new absolute electrometer, based on the attraction of two concentric cylinders, which is easy to construct and which gives continuous indications. An insulated hollow cylinder of metal is connected to the point whose potential is to be measured. A second cylinder is suspended, concentrically within the first, from the arm of a balance, which, is connected to the ground. A third cylinder slightly larger than the second, encloses its lower third and projects considerably below the first and outer cylinder. This cylinder, as well as a metallic screen between the cylinders and the balance beam, is connected to earth. The first or outer cylinder exerts upon the second or suspended cylinder an attraction upward. These two constitute a condenser, the length of the former in relation to the latter being such that in the middle section the equipotential surfaces between them are concentric cylinders and the lines of force radii; while above and below this the distribution varies. If now the suspended cylinder rises above the enclosing third cylinder by a small amount, the change in distribution may be considered to consist of a simple elongation of the uniform portion, the superior portion where the distribution is irregular being simply displaced. If F be the upward force on the suspended cylinder and dz its displacement, the work done by the electric forces is Fdz. But this work is equal to the increase of the energy of the system; and this is proportional to $\frac{1}{2}QV$, in which Q represents the increase of charge and V the potential of the outer cylinder. But $Q=CV$, the product of the capacity of a portion of the cylindrical condenser of height dz by the potential; and this capacity is equal to $\frac{dz}{2 \log \frac{R}{r}}$, in which R and r are the radii

of the inner and outer cylinders respectively. Whence

$$F\,dz = \frac{V^2\,dz}{4 \log \frac{R}{r}} \quad \text{and} \quad V^2 = 4F \log \frac{R}{r}$$

By measuring R and r in centimeters and F in dynes, V will be obtained in absolute C. G. S. units. To measure F, known weights are placed in a small scale pan above the suspended cylinder until equilibrium is obtained. This value in grams is converted into dynes by multiplying by g. The oscillations of the balance-beam are damped by means of a cardboard disk attached to it in place of the second pan and movable within a slightly larger cylindrical vessel of glass. Since within certain limits the force is independent of the position of the inner cylinder, a mirror may be attached above the knife edge and the displacements read with a telescope and scale; their value in dynes being obtained by multiplying the constant of displacement by the tangent of the inclination angle. This constant is determined experimentally once for all, by noting the angular displacement produced by known weights when the electrometer is not charged. Calculation shows that in the actual instrument as constructed, a want of coincidence of 3^{mm} between the axes of the cylinders changes F by only 0·003 of its value. A slight correction may be made for the stem of the inner cylinder. The results given by the apparatus are satisfactory.—*C. R.*, cii, 753–756, March, 1886.

G. F. B.

2. *On the Influence of Temperature on the Heat of Chemical Combination.*—Because of the rudimentary character of our knowledge of the influence exerted by temperature upon the heat of chemical combination, PICKERING has undertaken to investigate it, by measuring this heat of combination within the limits of ordinary atmospheric temperatures, about 25°. Since hydrated salts afford many instances of small energy of combination, and since such substances would be most likely to exhibit a variation in the heat of their formation within these narrow limits, these salts were chosen for the investigation. Whenever a salt is dissolved in water, the difference between the heat of solution in the anhydrous and hydrated states gives the heat of combination of the salt with its water of crystallization, provided the heat absorbed in the conversion of the solid water into liquid water in the second case, is subtracted from the latter. The author finds "that the relation between the constituent portions of the molecule of a complex solid undergoes a series of modifications as the temperature changes, the result of which is that the variations exhibited in the heat of combination, and consequently in the specific heat also, being conditioned by a different order of circumstances at different temperatures, exhibit irregularities of a very marked character." The summary and conclusions of this research we give in his own words: (1) The heat of dissolution of a salt at different temperatures is not represented by a straight

line, but by a curve, or generally by a series of curves. (2) Each of these curves probably indicates the formation and existence of some fresh hydrate in the solution. (3) The formation of higher hydrates as the temperature rises would not appear to hold good when we approach a temperature which is near the melting point of the solid hydrated salt, as in the case of sodium sulphate. (4) From the constant variations in the thermal phenomena attending dissolution at different temperatures, it follows that the specific heats of saline solutions exhibit similar variations, remaining constant, or even varying at a uniform rate, throughout very limited ranges only. (5) The heat of combination of a salt with its water of crystallization in the solid state undergoes similar series of changes. (6) From this it follows that the specific heat of such a salt is not a constant quantity, and that it is not exactly equal to the sum of that of the anhydrous salt and the solid water present, but is generally somewhat less. (7) The general tendency between 2° and 23° is toward an increase of the energy with which the water is combined. (8) Any temperature at which a higher hydrate is formed by a salt in solution is marked by a *decrease* in the heat of combination of the salt with its water of crystallization in the solid state. (9) The heat of combination of two sulphates to form a double salt is subject to variations of the same nature as that of the combination of a salt with water. (10) The variations in the heat of combination of the two salts is attended by variations of an opposite sign in the heat of combination of the double salt and the water combined with it. (11) Most of the salts here investigated show some points of similarity in the curves which they yield, but each possesses specific peculiarities. (12) The peculiarities exhibited by a single salt appear to be reproduced to a certain extent in the double salts which they form,—illustrated by the rise in the curves of both the magnesium salts at about 22° and the character of abruptness displayed in the case of both the copper salts."—*J. Chem. Soc.*, xlix, 260–311, May, 1886. G. F. B.

3. *On the Hypochlorites of Ethyl and Methyl.*—Some time ago in a preliminary paper, SANDMEYER showed that by mixing alcohol with strong aqueous hypochlorous acid, hypochlorous ether was separated as a yellow oil. The ready decomposition of the acid, however, caused the yield to be very small. The author now finds that almost the theoretical quantity can be obtained if the alcohol be mixed with caustic soda solution and chlorine gas be passed through the liquid, well cooled. For this purpose, a glass tube 3^{cm} in diameter and 40^{cm} long, drawn to a narrow neck at top and having a glass stopcock at bottom, placed in a Liebig condenser, was three-quarters filled with a solution of one part sodium hydrate and one part alcohol in nine parts of water, and, being slightly inclined from the horizontal, chlorine gas was passed in through the stopcock, the whole being cooled by a current of water. The gas was readily absorbed, the solution became yellow and turbid and a layer of yellow oil collected on the

surface. Just before the gas ceased to be absorbed the operation was stopped, the salt solution drawn off and the ethyl hypochlorite collected and dried. Repeating this experiment with methyl alcohol, a point was soon reached where the gas seemed no longer to be absorbed. But the gas evolved was not chlorine, since a test-tube of it violently exploded on the approach of a flame. Passed, first through a calcium chloride tube and then through a cooling mixture of ice and salt, it condensed to an exceedingly volatile yellow liquid of penetrating chlorine-like odor, which could be mixed with methyl alcohol without decomposition, and a drop of which on a porcelain surface exploded like dynamite on touching it with a flame, shattering the vessel. Its boiling point was fixed at 12° under a pressure of 726^{mm}. Analysis proved its formula to be CH_3OCl. Sulphurous oxide unites directly with methyl hypochlorite, forming methyl chlor-sulphonate, $CH_3 . OSO_2 Cl$, a colorless liquid with a powerful odor, boiling between 132° and 133°.—*Ber. Berl. Chem. Ges.*, xix, 857–861, May, 1886.

G. F. B.

4. *On the Existence and Formation of Nitrates in Plants.*—Berthelot and André have conducted, at the Meudon station of plant-chemistry, an elaborate series of investigations on the existence of nitrates in plants, the results of which they have published in four separate memoirs, entitled respectively: Methods of analysis; the universal presence of nitrates in the vegetable kingdom; the study of nitrates in the different parts of plants and at various stages of growth; and an examination of the various sources from which these nitrates may come. They find that *Borrago officinalis*, and the *Amarantaceæ*, of all the large variety of plants examined, contain most nitrates; that the stem contains most, and the roots next; that nitrates increase from germination until just before flowering, and then diminish; increasing again however after the reproductive function is completed and even after the death of the plant. Grown on a hectare of surface, *Borrago officinalis* gives 120 kilograms of saltpeter; *Amarantus bicolor*, 128 kilograms; *A. caudatus*, 140 kilograms; *A. pyramidalis*, 163 kilograms; and *A. giganteus*, 320 kilograms. As to the origin of this nitrate, four sources may be suggested: (1) the fertilizers used, (2) the soil, (3) the nitric acid of the atmosphere and (4) its formation in the plant itself. The first is excluded by the fact that the manures used contained only a trace of nitrates. With regard to the soil, analysis showed that the earth over a hectare, to the depth of 0·325 meter contained 54 kilograms potassium nitrate; which is less than half that contained in the *Borrago* grown on this surface, and less than one-sixth of that in the gigantic Amaranth. Moreover direct experiment showed that the nitrates in the soil did not perceptibly increase during the growth in it of the plant; and that, even when washed out of the soil by the rain, the quantity in the plant remained sensibly the same. As to the atmosphere, analyses made at the Montsouris observatory showed that the nitrate contained

in the rain which fell during the season, amounted upon a hectare to 4·4 kilograms only: scarcely one-twentieth of that in the soil. The authors hence conclude that the formation of nitrates in plants is an established fact and seems to result from the special action of a more general function of the cellules, the function which gives rise to oxidations; that is to say, the same function which produces carbonic acid and carbonates, oxalic, tartaric, citric, malic and other peroxygenized acids. The further investigation of this function is already in progress at Meudon.—*Ann. Chim. Phys.*, VI, viii, 5–128, May, 1886. G. F. B.

5. *On the earth Yα and Mosandria.*—Among the earths of samarskite which accumulate in the middle fractions, CROOKES has found one (or perhaps a group) giving a well defined phosphorescent spectrum in the radiant matter tube, consisting of nine bands, of wave-lengths 644·6, 641·5, 618·9, 609·4, 597·0, 567·6, 561·3, 549·5 and 540·6. When sufficiently pure, the earth giving this spectrum presents the characteristic properties of that discovered by Marignac and called Yα; as the author had proved by a comparison of his own material with a sample of Yα sent to him by Marignac. A sample of mosandria, prepared by Lawrence Smith, sent to Crookes by Marignac gave a phosphorescent spectrum showing that it is not a single substance and that it contains the earth yttria.

In the following paper, LECOQ DE BOISBAUDRAN gives the results of his examination of a specimen of impure mosandria from the laboratory of the late Lawrence Smith, sent to him by Dr. Marvin of Louisville, Ky. It contained much didymia and samaria; and on removing these by fractioning with ammonia, the residue gave brilliantly the electric spectrum of Yα, so that at first thought, the author considered this the purified material which Smith described. Marignac however called his attention to the fact that Smith described mosandria as a highly colored orange-yellow oxide, while Yα as prepared by Marignac is nearly colorless, and would probably be white if pure. In fact, the earth obtained from the crude mosandria is dark orange-yellow in color and gives the phosphorescent bands Zα and Zβ, the latter predominating. Hence it appears probable to the author that the mosandria of Lawrence Smith consists of a mixture of the earths Yα and terbia, the latter in excess; thus agreeing in opinion with Marignac.—*C. R.*, cii, 646–648, March, 1886. G. F. B.

6. *On the Spontaneous Polymerization of volatile Hydrocarbons at ordinary temperatures.*—Sir H. E. ROSCOE has called attention to the production of a solid crystalline hydrocarbon $C_{10}H_{12}$ from the most volatile fraction obtained by decomposing crude phenol at a red heat. This fraction boiled between 20° and 40°; and on standing several weeks was converted into a solid polymer, fusing at 32·9° and distilling at 160° to 170°, though with decomposition. Its sp. gr. was 1·012 at 17·5° and its vapor density was 4·39 and 4·57 in two experiments. It oxidizes to a yellow resin in the air and yields a nitro and a brom-derivative.—*Liebig's Annalen*, ccxxxii, 348–352, April, 1886. G. F. B.

II. Geology and Natural History.

1. *The Cretaceous Flora of North America.*—An abstract of a paper by Professor Newberry on the Cretaceous Flora of North America, in the Trans. N. Y. Acad. Sci., No. 5, 1886, mentions the discovery of great numbers of leaves of Angiosperms in the Raritan or Amboy clays of the New Jersey Cretaceous, and states that the author has already fifty quarto plates of drawings ready for the engraver. The clays are largely explored for making brick and pottery. Professor Newberry regards the clays as the equivalent of the western Dakota group, the Atane beds of California, and of the Upper Greensand of England. The Angiospermous leaves, of which there are fifty to sixty species, pertain to the genera *Liriodendron*, *Magnolia*, *Sassafras*, *Aralia*, *Celastrus*, *Celastrophyllum*, *Salix*, and what Heer has called *Hedera*, *Ficus*, *Diospyros*, *Juglans* and others. With these, many specimens have been found of a helianthoid species of the Compositæ, *having a flower three to four inches* in diameter, in which the ray florets (?) were scarious and persistent like those of Heliochrysum.

There are also fine species of two genera of Leguminosæ, Bauhinia and Hymænea, not before reported from the North American Cretaceous. The specimens gathered include also about a dozen species of Conifers, as many Ferns, and two or three Cycads. "Taken together," says Professor Newberry, "this flora is of surprisingly high botanical rank, quite as much so as that obtained from any Tertiary strata." The Mill Creek beds of British America are referred by him to the same horizon; and the Peace River are made the equivalent of the Chalk.

From the Potomac clays of Virginia, a still older Cretaceous flora, supposed to be Neocomian, has been found by Professor Fontaine, where "a large number of species of Cycads, Conifers and Ferns occur along with a few Angiosperms." The plants of beds of the Queen Charlotte Islands are referred to the same horizon.

2. *Periods of enlargement and diminution in the Glaciers of the Alps.*—Mr. Forel reports, from the data which he has collected with much care, that there have been this century five periods in the Alpine glaciers; of enlargement from 1800 (?) to 1815; of diminution from 1815 to 1830; of enlargement from 1830 to 1845; of diminution from 1845 to 1875; and of enlargement again from 1875 onward. He remarks further that these periods correspond with those deduced by Mr. C. Lang for the variations in precipitation and temperature of the air; and consequently, that the enlargement of the glaciers has gone forward in the cold and rainy period and the diminution in the warm and dry.—*Archives Sci. Phys. Nat.*, May 15, 1886, p. 503.

3. *Maps published by the U. S. Geological Survey.*—The Geological Survey, in carrying forward the preparation of a geologi-

cal atlas of the United States ordered by the General Government, has had topographical surveyors in the field, in different parts of the country; and the forty-five maps now issued are part of the results thus far completed. They cover portions of Utah, Nevada, Arizona, Texas, Missouri, Kansas and Alabama. Each comprises about one degree in latitude and the same in longitude, and measures 17 to 18 inches by 12 to 14. Altitudes are marked by contour lines, with the addition of numerals on the peaks or higher points, and the rivers are printed in blue. The maps are finely engraved, of convenient size, and beautiful in appearance; and when completed and supplied with geological coloring and details, will be esteemed at home and abroad as very important work well done. The country is large and the expense will be large; but the great work should be carried through to its full completion whatever the cost.

4. *Stromatopora.*—Dr. C. Rominger criticises the paper of Nicholson and Murie on the structure of Stromatopora, in the Proc. Nat. Sci., Philadelphia, of 1886, pp. 39–56.

5. *Palæontologica Indica.*—Numerous Bryozoa, Annelida and Echinodermata of the Productus Limestone in the Salt Range, are described by Dr. Wm. Waagen in a part of the quarto publications of 1885, and beautifully illustrated on plates 87 to 96. All the plates but two are devoted to the Bryozoa. The author excludes from the Bryozoa the genera Chætetes, Stenopora, Monticulipora, regarding them as probably belonging with the tabulate corals, and includes therefore only two families, the Fenestrellidæ and Thamniscidæ.

6. *Microscopic characters of some specimens of devitrified glass;* by D. Henman and Frank Rutley, (Proc. Roy. Soc. 1885, p. 87).—The authors describe the effects obtained by microscopic examination of various specimens of devitrified glass. Devitrification was obtained by covering the floor of the kiln with 2½ inches of sand, putting on this the glass, and then a layer of sand 3 and 6 inches thick. By slow heating, in six days the glass had become dull red, and in six more a bright red, without fusion. This temperature was maintained for twelve days and then the kiln opened and quickly cooled. In other experiments, the time was varied. It was found that with heating for twenty to thirty days, as above described, the glass was thoroughly devitrified; that if the heat was kept below dull red heat, or about 650° F., there was no devitrification; and if cooled immediately after heating to 650° F., allowing four hours for the cooling, the devitrification was slight and mostly on the surfaces. The devitrification goes on from the surface inward. When least complete, stellate or radiating crystallites are formed; and when a little more so there is usually a tendency to a spherulitic structure; and when complete, it is generally a mass of more or less distinct divergent groups, separated sometimes by an angular outline. There are in some cases spherulites, with or without a radiated structure.

7. *E. O. Ulrich's Contributions to American Palæontology*, Vol. I. Cincinnati, 1886.—Mr. Ulrich in his prefatory remarks

on the first page of this first number of his Palæontological Contributions, after alluding to the difficulties in the way of publication of papers requiring illustrations, announces that to make himself independent, he proposes to establish a series of private publications, under the above title, to appear as material demands it. He expresses his indebtedness to Mr. G. K. Greene of New Albany, Indiana, for his generous financial aid with reference to the number now published. Paleontologists and others may aid his enterprise and the science by subscribing for the Journal. This first number contains a valuable paper by Mr. Ulrich, consisting of descriptions of New Silurian and Devonian Fossils (Corals, Mollusca, etc.), which is illustrated by three excellent plates.

8. *Class-book of Geology;* by ARCHIBALD GEIKIE, LL.D., F.R.S. 516 pp. 12 mo., illustrated with woodcuts. London, 1886, (Macmillan & Co., N. Y.)—In this "Class-book of Geology" Dr. Geikie presents the science in a simple and readable form, for the benefit especially of young students in the department, and also for the general public. The operations going on over the globe are explained by various examples and then applied to the illustration of the events in geological history. From an account of the action of water in rivers and oceans and their results, the work passes to the subject of volcanoes; then devotes many pages to minerals and rocks; and afterward treats of stratification, volcanic eruptions, mineral veins, fossils, and the general system of progress through the geological periods. The illustrations are good, and in part from the note-book of the able author.

9. *Ancient Herbaria. Histoire des Herbiers*, par le DR. SAINT-LAGER. Paris, Baillière et fils, 1885, pp. 120, 8vo.—The author of this treatise shows us that only in the seventeenth century did the word *herbarium* acquire its present meaning, that of a collection of pressed specimens of herbage and flowers, prepared for botanical uses. The *Herbarius* of the Romans was the herb-collector. *Herbarium* down through the sixteenth century was the common name of a *Historia Plantarum* or other botanical treatise. Next it came to mean a collection of *simples*, a sort of museum of the actual herbs, roots, fruits, etc., used in medicine or the arts. Sprengel, in his *Historia Rei Herbariæ*, in telling of the botanic garden which Brassavola established on an island of the Po near Ferrara, adds "herbarium ipse collegat ditissimum." But the collection was one of simples, as is well known from contemporary evidence, not of botanical specimens. These came after the botanic garden, naturally, and the first recorded name of such a collection is by Adrien Spiegel (Spigelius), in 1606—that of *Hortus hiemalis*. When plants are all dead in winter, he says, the only resource is to botanize in *horti hiemales*, that is, in books filled with dried specimens stuck fast to the leaves. *Hortus siccus* soon came to be the name, lasting down to our days. But Tournefort brought in the now prevalent name before 1700, defining it thus: "*Herbarium sive hortum siccum appellant collectionem*

plantarum exsiccatarum que in codicibus vel capsis asservantur, ut quavis anni tempestate inspici possent.

Whether the first-known maker of such a collection of pressed specimens was Ghini, of Pisa, or John Falconer, an Englishman or probably a Scotchman, seems unsettled. Anyhow, it is odd that neither of them has had a genus of plants named for him by any of the long line of their successors.

The history of the most ancient herbaria known has now been carefully written up by M. Saint-Lager, of Lyons. Of John Falconer's herbarium it is only known that it was admired by Italian botanists at Ferrara in the year 1545, and was examined by Turner at London, on the owner's return to his native country. The most ancient herbaria now extant, or partially so, are those of Aldrovandi, commenced in about the year 1553 (and which contains as many as 5,000 specimens in seventeen volumes); of Girault, of Lyons, which bears the date of 1558, and of Cesalpin, which bears the date of 1563. The first of these is preserved at Bologna, its proper home, although it was once taken to Paris; the second is at the Jardin des Plantes; the third is at Florence. Next in chronological order is that of Rauwolf (who died in 1596), preserved at Leyden; then that of Caspar Bauhin (who died in 1613), preserved at Basle in excellent condition. The curious reader will find a full account of these herbaria and much interesting lore besides, in M. Saint-Lager's essay. A. G.

10. *The Journal of the Linnæan Society, Botany*, vol. xxii, contains unusually interesting papers, to which, however, we can make only brief reference. The first paper is Mr. John Ball's *Contributions to the Flora of the Peruvian Andes*, etc., of which an extended review has already been given to our readers. In the succeeding number (pp. 137–168), under the title of *Notes on the Botany of Western South America*, Mr. Ball, after sketching the features of the climate of the seaboard from Panama to the Chonos Archipelago, specifies the principal plants he collected at several points, characterizing also a few new species, and adding various critical annotations and interesting suggestions. Mr. Bolus gives a second part of his *Contributions to South African Botany*, relating to the *Orchideæ*. The Rev. George Henslow follows with his suggestive *Contribution to the Study of the relative effects of different parts of the Solar Spectrum on the Transpiration of Plants.* He confirms Weisner's results, adding "somewhat tentatively," the "additional fact that yellow light has a retarding influence upon transpiration." Mr. Francis Darwin here publishes the results and many of the details of his researches —begun in connection with his lamented father in 1878— *On the Relation between the "Bloom" on Leaves and the distribution of the Stomates.* The point is, that one function of bloom is to be found in the protection of the stomata from wet, which would interfere with the prompt ingress and egress of air. It is familiarly known that in very many leaves the stomates occupy the lower surface, either exclusively or most largely, and this is the face least exposed to rain. But it appears that whenever the

upper surface has a bloom, and so to a considerable extent sheds the rain, there is a strong tendency to the accumulation of stomates on that surface. A paper by Mr. Ridley on *Orchids from Madagascar*, and a readable narrative by C. Baron Clarke, of *Observations made in a Journey to the Naga Hills, in Upper India*, need not be remarked upon. A remaining article, *Contributions to the History of certain species of Conifers*, by Dr. Maxwell T. Masters, pp. 169–212, with nine plates and copious figures in the letterpress, is of general interest and importance. The illustrations and much of the text are reproduced from the Gardeners' Chronicle in this more convenient and accessible form. The species here discussed, with which we in this country are most concerned, are *Abies amabilis*, *A. grandis*, *A. concolor*, *A. subalpina*, and *A. nobilis* with *magnifica*, the observations of Engelmann and Sargent, as well as those of Hooker, supplemented by Dr. Masters's own critical studies. We trust that this paper is only the first of a series.

Volume xxiii opens, and the first number (150) is filled, with a paper of much botanical importance, viz: *An Enumeration of all the Plants known from China proper, Formosa, Hainan, Corea, the Luchu Archipelago, and the Island of Hongkong, together with their Distribution and Synonymy*, by Francis Blackwell Forbes, F.L.S., etc., and Wm. Botting Hemsley, A.L.S., etc. This first portion extends from the *Ranunculaceæ* to the *Ternstræmiaceæ*. It will fill the volume, and when completed will be separately issued, with introduction and summary, under the title of *Index Floræ Sinensis*. A. G.

11. *Heterogeneous Grafting.*—Strasburger, in the Berichte der Deutschen Bot. Gesellschaft, vol. iii, records some curious results of his experiments in intergrafting various herbaceous *Solanaceæ*. Thus, he successfully grafted species of Stramonium, and common Tobacco plant, Henbane, Atropa Belladonna, and Petunia upon the common Potato plant. Grafts of *Datura Stramonium* and *Nicotiana Tabacum* took remarkably well, the plants growing freely and coming into flower. Tschudy, however, long ago had grafted *Lycopersicum* upon a Potato stock, and so had gathered potatoes from the bottom and tomatoes from the tops of the same plant; but this is not so extraordinary, the two plants being no essentially congeneric.

The most remarkable result of Strasburger's trials was that, when *Datura Stramonium* was grafted upon a Potato plant, the potatoes borne by the latter, to all appearance normal, were found to be impregnated with atropine. He does not say whether these grafted into *Nictiana Tabacum* had their tubers infected with nicotine. A. G.

12. *Contagious diseases of Insects.*—A number of the Bulletin of the Illinois State Laboratory of Natural History, recently issued contains a very interesting paper on this subject, prepared by S. A. Forbes, from careful personal studies and experiments. It constitutes Article iv, in Volume ii, of the Bulletin.

13. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. iv, 1882–1884. Davenport, Iowa, 1886.—This new volume of 348 pages, contains papers on the plants of Iowa; a new Arctostaphylos from California; the genus Chorizanthe; on a new genus and species of Blastoid, by C. Wachsmuth; and on new species of Blastoids, by W. H. Barris, with two excellent plates; but it is occupied chiefly with ethnographic papers which are illustrated by many figures of the pottery among the ancient Indians of the Mississippi Valley. It contains also a biographical sketch of Dr. Robert James Farquharson, an active member of the Davenport Academy of Sciences.

14. *Annalen der k. k. Naturhistorischen Hofmuseums redigirt von Dr. Franz Ritter von Hauer.*—Roy. 8vo. Vienna.—This new Journal was commenced with the current year, under the editorial charge of Dr. von Hauer, who now is Director of the Royal Museum at Vienna. The second number contains the following papers: on the Miocene Pteropods of Austria-Hungary by E. Kittl; on new and rare Antilopes in the Museum, by Dr. Fr. Kohl; on the Paleozoic Insects, by Dr. Fr. Brauer; on Specific Gravity determinations of Minerals, by Dr. V. Goldschmidt; on the Crystalline form of Tellurite and Valentinite, by Dr. A. Brezina. The subjects are illustrated by seven plates, besides woodcuts in the text.

V. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*—The thirty-fifth meeting will commence at Buffalo, N. Y., on the 18th of August. This will be the third welcome of the city to the Association. The circular of the local committee states that the high school, recently improved and enlarged, has been placed at the disposal of the Association for the daily sessions; and that the offices of the permanent and local secretaries, as well as those of the different committees, will be located in the building. Buffalo is one of the leading railroad centers of the United States; and, through the committee already eighty railroads, mentioned in the circular, have consented to give reduced rates to members of the Association, eastern roads charging 1½ cents a mile for the round trip, and the western one-third rates. Detailed information as to railroads, hotels, and other arrangements, may be obtained by addressing the Secretary of the Local Committee, Dr. Julius Pohlman. Arrangements are in progress for excursions; and besides, the Botanical Club of Buffalo is arranging an excursion and reception for the botanical members of the Association; and the same with the Entomological Club of Buffalo. The permanent secretary, Professor F. W. Putnam, of Salem, Mass., should be addressed with reference to papers for the meeting.

Flow of water in open channels, pipes, sewers, conduits, etc., with tables based on the formulæ of D'Arcy, Kulter and Bazin, by P. J. Flynn, Civil Engineer. 118 pp. 18mo. New York, 1886 (D. Van Nostrand.)